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# **Base (100-Year) Flood Elevations for Selected Sites in Livingston County, Missouri**

By Rodney E. Southard and Joseph M. Richards

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For additional information write to:

**District Chief  
U.S. Geological Survey, WRD  
1400 Independence Road  
Mail Stop 100  
Rolla, Missouri 65401**

Copies of this report can be purchased from:

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## VERTICAL DATUM

Vertical coordinate information is referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29). **Elevation**, as used in this report, refers to distance above or below NGVD 29. NGVD 29 can be converted to the North American Vertical Datum of 1988 (NAVD 88) by using the National Geodetic Survey conversion utility available at URL <http://www.ngs.noaa.gov/TOOLS/Vertcon/vertcon.html>.

# Base (100-Year) Flood Elevations for Selected Sites in Livingston County, Missouri

By Rodney E. Southard *and* Joseph M. Richards

## Abstract

The primary criteria for community participation in the National Flood Insurance Program is the adoption and enforcement of floodplain management requirements that minimize the potential for flood damages to existing and proposed development in flood-hazard areas. This report provides base flood elevations (BFE) for a 100-year recurrence-interval flood for use in the management and regulation of 18 flood-hazard areas designated by the Federal Emergency Management Agency as approximate Zone A areas in Livingston County, Missouri.

The one-dimensional surface-water flow models HEC-RAS and Water-Surface PROfile (WSPRO) were used to compute base (100-year) flood elevations for 18 Zone A sites. The HEC-RAS model was used at BFE sites 1 to 6, 9, 10, and 15 to 18. The WSPRO model was used at BFE sites 7, 8, and 11 to 14. The 18 sites are all located in Livingston County, Missouri, at U.S., State, or County road crossings, and the base flood elevation was determined at the upstream side of each crossing. The base (100-year) flood elevations for BFE 1, 2, and 3 on Shoal Creek at Dawn and Shoal Creek Drainage Ditch near Dawn are 701.0, 701.0, and 696.5 feet, respectively. The base (100-year) flood elevations for BFE 4 and 5 on Indian Branch near Sampsel and a tributary to Indian Branch near Sampsel are 711.7 and 755.4 feet, respectively. Site BFE 6 is located on Honey Creek near Farmersville and the base (100-year) flood elevation for this site is 730.8 feet. One site (BFE 7) is located

on No Creek near Farmersville. The base (100-year) flood elevation for this site is 731.3 feet. Site BFE 8 is located on Crooked Creek near Chillicothe and the base (100-year) elevation is 716.4 feet. One site (BFE 9) is located on a tributary to Coon Creek at Chillicothe. The base (100-year) flood elevation for this site is 734.9 feet. Two sites (BFE 10 and 11) are located on Blackwell Branch at Chillicothe. The base (100-year) flood elevation for BFE 10 is 738.9 feet and for BFE 11 is 701.7 feet. The base (100-year) flood elevation for BFE 12 on Medicine Creek near Chula is 721.7 feet. Sites BFE 13 and 15 are on Muddy Creek and for BFE 14 is on Little Muddy Creek near Chula. The base (100-year) flood elevations for BFE 13 and 15 are 733.0 and 717.9 feet, respectively and for BFE 14 is 734.6 feet. Downstream from BFE 12 is site BFE 16 on Medicine Creek near Wheeling. The base (100-year) flood elevation for site BFE 16 is 686.1 feet. One site (BFE 17) is located on Campbell Creek near Bedford. The base (100-year) flood elevation at this site is 691.8 feet. Site BFE 18 is located on Towstring Creek near Hale. The base (100-year) flood elevation for site BFE 18 is 667.4 feet.

## INTRODUCTION

In 1968, the United States Congress passed the National Flood Insurance Act, which created the National Flood Insurance Program. Congress recognized that the success of this program requires that community participation be widespread and that detailed flood-insurance studies be conducted to accu-

rately assess the flood risk within each participating flood-prone community (U.S. Department of Housing and Urban Development, 1995). The primary criteria for community participation in the National Flood Insurance Program is the adoption and enforcement of floodplain management requirements. The purpose of the requirements is to minimize the potential for flood damages to existing and proposed development in flood-hazard areas.

The Housing and Urban Development Act of 1969 expanded participation in the National Flood Insurance Program by authorizing an Emergency Program under which insurance coverage could be provided before completion of the communities' detailed flood-insurance studies. Before these studies could be conducted for the communities, Flood Hazard Boundary Maps were prepared by engineers, surveyors, and developers using either available data or approximate engineering methods. The Flood Hazard Boundary Maps identify the approximate areas within a community subject to inundation by a 100-year recurrence-interval flood. These areas are referred to as Zone A areas on the boundary maps. Zone A areas have a one percent chance of being inundated by a 100-year flood in any given year. The Flood Hazard Boundary Map was intended to assist communities in managing floodplain development and insurance agents and property owners in identifying areas where the purchase of flood insurance was advisable (U.S. Department of Housing and Urban Development, 1995).

The Flood Disaster Protection Act of 1973, which amended the 1968 National Flood Insurance Act, required that flood-prone communities be notified of their flood hazards to encourage insurance program participation. This was accomplished through publishing Flood Hazard Boundary Maps for all communities that were identified as containing flood-hazard areas. The initial Flood Hazard Boundary Maps were prepared using results from detailed flood-insurance studies. As early as 1976, the Federal Emergency Management Agency (FEMA) recognized that some communities did not require a detailed flood study because few buildings existed in the floodplain and development plans were minimal. Shortly thereafter, FEMA began designating communities with sparse existing and planned development in floodplains as having approximate Zone A areas on the Flood Insurance Rate Map (U.S. Department of Housing and Urban Development, 1995). To minimize study costs,

the approximate Zone A areas were to be analyzed using less-detailed methodologies than those used in detailed flood-insurance studies.

In areas designated as approximate Zone A, where base (100-year) flood elevations (BFEs) have not been provided by FEMA, communities must adopt and enforce floodplain management regulations that meet minimal National Flood Insurance Program standards (U.S. Department of Housing and Urban Development, 1995). However, in Zone A areas where base flood elevations are determined, communities are better able to manage and protect property susceptible to floods equal to or less than a 100-year flood. The U.S. Geological Survey (USGS), in cooperation with the State Emergency Management Agency, has completed a study using one-dimensional surface-water flow-models to compute base (100-year) flood elevations for 18 approximate Zone A sites in Livingston County, Missouri. The 18 selected sites are located at U.S., State, or County road crossings, and the base flood elevation for a site was determined on the upstream side of each crossing. This report presents the results of that study.

## DESCRIPTION OF THE STUDY AREA

Livingston County (fig. 1), population of about 14,500, is in the north-central part of Missouri and covers about 538 mi<sup>2</sup> (square miles). Chillicothe, in central Livingston County, is the county seat, and has a population of about 8,800. The county is economically dependent on farming or farm-related businesses. Farming operations mainly consist of growing row crops such as soybeans and corn.

Topography varies in Livingston County, ranging from gently sloping to moderately steep in the uplands and ridgetops, to nearly level to gently sloping along the Grand River. Soils in the county range from moderate to poorly drained in the uplands and ridgetops to moderate to poorly drained loamy and clayey along the Grand River. The Grand River flows through Livingston County from the west to the southeast corner (Allgood and Persinger, 1979). The climate of Livingston County is characteristic of the northwest prairie of the State of Missouri (Huff and Angel, 1992). Statistical analyses of climatological records in Huff and Angel (1992) indicate 100-year recurrence-interval rainfall totals for the 1-, 12-, and 24-hour storm periods



**Figure 1.** Location of base (100-year) flood elevation sites in Livingston County, Missouri.

were 3.43, 6.35, and 7.30 in. (inches), respectively. The annual mean rainfall for the city of Chillicothe is 37.81 in. from 1971 to 2000.

## HYDROLOGIC AND HYDRAULIC ANALYSES

Several hydrologic or hydraulic methods can be used to estimate flood discharges for approximate Zone A areas. For this study, base (100-year) flood discharges for all sites were estimated using the regression equation (Region I) in Alexander and Wilson (1995). This regression equation for unregulated streams in rural Missouri requires computation of two basin characteristics: drainage area and main-channel slope.

The one-dimensional surface-water flow model, HEC-RAS, developed by the U.S. Army Corps of Engineers (1997), was used in this study to compute base (100-year) flood elevations at sites BFE 1 to 6, 9, 10, and 15 to 18. HEC-RAS is based on the principle of conservation of streamflow energy, which states that the energy at the upstream valley section is equal to the streamflow energy at the downstream section plus the friction and transition losses between the two sections. Starting water-surface elevations were verified by normal-depth computations at the farthest downstream valley cross section. Normal depth is the depth expected for a stream when the flow is uniform and steady (U.S. Department of Housing and Urban Development, 1995).

To supplement the data for this study, results of an ongoing scour project with the Missouri Department of Transportation (MoDOT) were included in this report. The USGS, in cooperation with MoDOT, is evaluating the potential for bridge scour at selected bridges throughout the State. After preliminary evaluations, bridges identified as being susceptible to scour were selected for step-backwater analyses to estimate scour depths. In the scour project, the step-backwater model Water-Surface PROfile (WSPRO; Shearman, 1990) was used to route the 100-year peak discharge through the selected bridges. Base (100-year) flood elevations computed at the upstream side of the bridges using the WSPRO model are provided in the results for this study. In Livingston County, seven scour-susceptible bridges were identified at sites BFE 1, 7, 8, and 11 to 14 (R.J. Huizinga, U.S. Geological Survey, written commun., 2002).

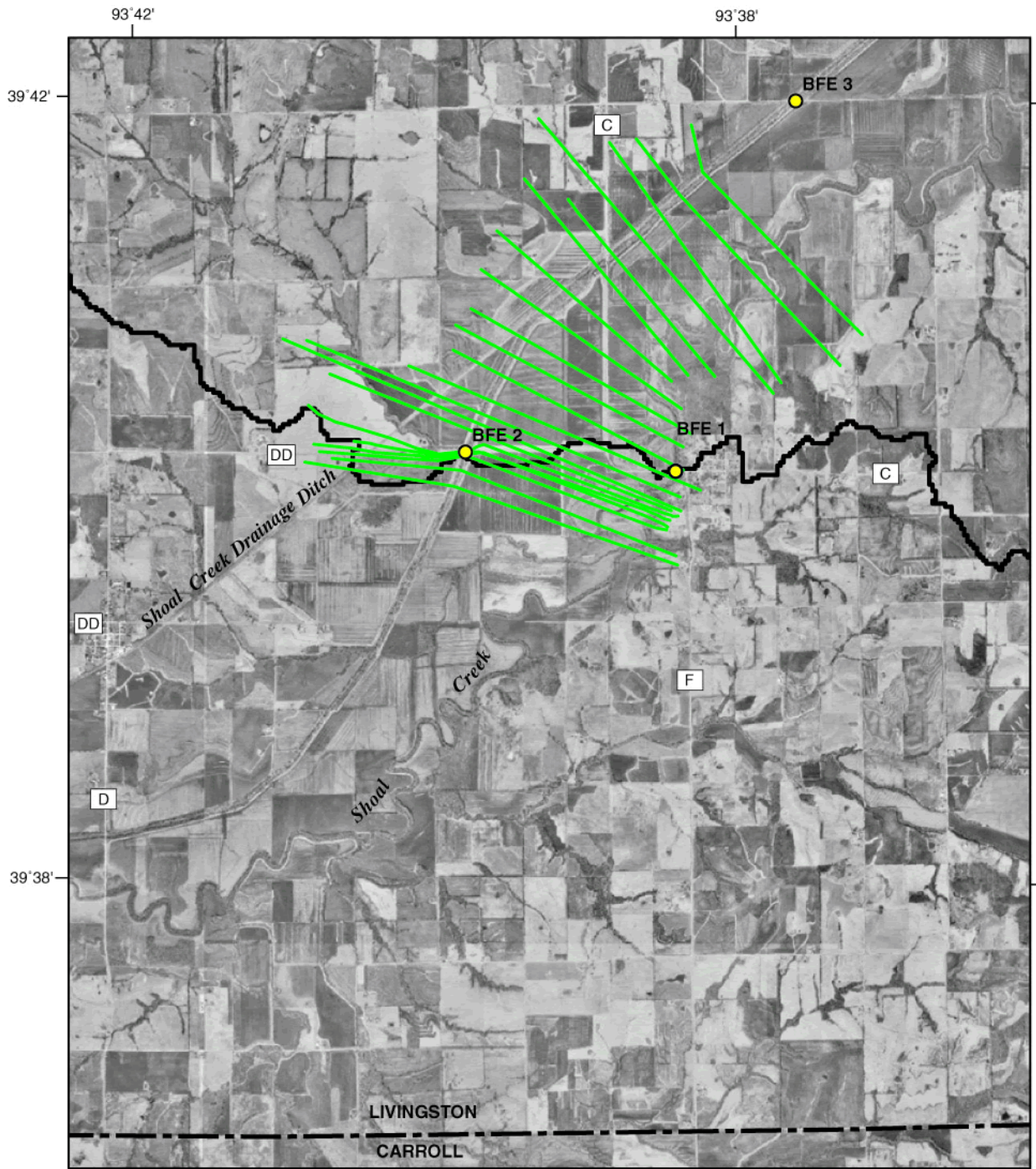
The hydraulic analyses for this study are based on unobstructed flow conditions. Computed base (100-year) flood elevations are valid if hydraulic structures (bridges) remain unobstructed and channel and over-bank flow conditions remain essentially unchanged. Elevations are referenced to the National Geodetic Vertical Datum of 1929 (NGVD 29) in this report. Elevations, locations, and descriptions of reference marks are given in table 1, in the "Supplemental Data" section.

### Base Flood Elevation for Sites BFE 1 and 2

Site BFE 1 is located on Shoal Creek, at State Highway C at Dawn, and site BFE 2 is located on the Shoal Creek Drainage Ditch at State Highway DD, approximately 1.5 mi (miles) west of Dawn, in the southwest corner of Livingston County (figs. 1 and 2). Shoal Creek and Shoal Creek Drainage Ditch flow in a northeasterly direction and roughly parallel to each other for about 8.5 mi. A series of levees are in place between the natural Shoal Creek channel and the Shoal Creek Drainage Ditch throughout this reach. The levees were not designed to contain a large flood such as the 100-year recurrence-interval flood discharge used to determine the base (100-year) flood elevation. Thus, cross sections were developed for the entire floodplain at sites BFE 1 and 2. At site BFE 1, the channel-top width is about 80 ft (foot) with an average channel depth of about 10 ft in the vicinity of State Highway C. At site BFE 2, the channel-top width is about 140 ft with an average channel depth of about 12 ft in the vicinity of State Highway DD. Hydrologically, sites BFE 1 and 2 were considered to be at the same location within the Shoal Creek drainage basin. The drainage area upstream from sites BFE 1 and 2 is 566 mi<sup>2</sup>, and the basin predominately is farmland (rural). The 100-year recurrence-interval discharge computed using the regression equation from Alexander and Wilson (1995) estimates a base (100-year) flood of 37,100 ft<sup>3</sup>/s (cubic foot per second) for each site (table 2).

The base (100-year) flood elevation for sites BFE 1 and 2 is 701.0 ft (table 2). Twenty-one cross sections were used in the HEC-RAS analyses to determine BFE 1 and 2. Cross sections immediately upstream and downstream from State Highways C and DD were obtained by field (transit-stadia) survey during this study and from data obtained during the scour study at BFE 1 (fig. 2). Other cross sections were obtained by



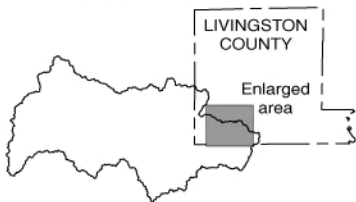


Base from U.S. Geological Survey digital orthophoto quarter-quadrangle, 1:12,000, 1999  
and digital data, 1:24,000, 1995  
Universal Transverse Mercator projection  
Zone 15

0 0.5 1 MILE  
0 0.5 1 KILOMETER

#### EXPLANATION

- BFE 1 BASE FLOOD ELEVATION SITE AND NUMBER
- CROSS-SECTION LOCATION
- BASIN BOUNDARY



**Figure 2.** Shoa Creek base (100-year) flood elevation site (BFE 1) and Shoa Creek Drainage Ditch base (100-year) flood elevation site (BFE 2) near Dawn, Missouri.

**Table 2.** Summary of base (100-year) flood discharges and elevations for selected sites in Livingston County, Missouri[mi<sup>2</sup>, square mile; ft/mi, foot per mile; ft<sup>3</sup>/s, cubic foot per second; ft, foot; NGVD 29, National Geodetic Vertical Datum of 1929]

Map number (fig. 1)	Stream and location	Drainage area (A) (mi <sup>2</sup> )	Main-channel slope (S) (ft/mi)	Base (100-year) flood discharge <sup>a</sup> (ft <sup>3</sup> /s)	Base (100-year) flood elevation <sup>b</sup> (ft)
BFE 1	Shoal Creek at State Highway C at Dawn	566	3.76	37,100	701.0
BFE 2	Shoal Creek Drainage Ditch at State Highway DD near Dawn	566	3.76	37,100	701.0
BFE 3	Shoal Creek Drainage Ditch at County Road 418 near Dawn	589	3.60	37,500	696.5
BFE 4	Indian Branch at State Highway N at Sampsel	22.6	13.1	6,990	711.7
BFE 5	Tributary to Indian Branch at County Road 515 near Sampsel	2.50	63.1	2,860	755.4
BFE 6	Honey Creek at County Road 202 near Farmersville	106	6.99	15,400	730.8
BFE 7	No Creek at U.S. Highway 65 near Farmersville	67.0	6.82	11,300	731.3 <sup>c</sup>
BFE 8	Crooked Creek at U.S. Highway 65 near Chillicothe	13.6	16.6	5,450	716.4 <sup>c</sup>
BFE 9	Tributary to Coon Creek at State Highway 190 at Chillicothe	2.20	32.1	2,080	734.9
BFE 10	Blackwell Branch at County Road 232 at Chillicothe	3.43	28.0	2,660	738.9
BFE 11	Blackwell Branch at U.S. Highway 36 at Chillicothe	7.37	18.4	3,790	701.7 <sup>c</sup>
BFE 12	Medicine Creek at State Highway K near Chula	395	4.28	30,700	721.7 <sup>c</sup>
BFE 13	Muddy Creek at State Highway KK near Chula	44.3	8.58	9,360	733.0 <sup>c</sup>
BFE 14	Little Muddy Creek at State Highway KK near Chula	19.3	12.3	6,170	734.6 <sup>c</sup>
BFE 15	Muddy Creek at County Road 216 near Chula	72.2	7.98	12,600	717.9
BFE 16	Medicine Creek at U.S. Highway 36 near Wheeling	520	4.38	37,000	686.1
BFE 17	Campbell Creek at County Road 310 near Bedford	4.19	39.5	3,410	691.8
BFE 18	Towstring Creek at County Road 387 near Hale	11.4	25.2	5,600	667.4

<sup>a</sup> Alexander and Wilson (1995),  $Q_{100}=376(a)^{0.652}(S)^{0.346}$ , Region 1.<sup>b</sup> Above NGVD29.<sup>c</sup> R. J. Huizinga, U.S. Geological Survey, written commun., 2002.

contouring 30-m (meter) (98.4-ft) digital elevation model (DEM) data at a 1-m (3.28-ft) contour interval and cutting cross sections on the contoured surface. These cross sections were then modified on the basis of field surveys and channel data obtained during the site visit. Pertinent bridge and embankment geometry of piers, wingwalls, abutment and embankment slopes, and road profile were obtained from the field survey. Manning's roughness coefficients used in the HEC-RAS analyses were obtained from the field survey (Arcement and Schneider, 1989) and ranged from 0.040 to 0.060 for the main channel and from 0.070 to 0.080 for the floodplain. The starting water-surface elevation was determined from the step-backwater analyses conducted at site BFE 3 located downstream. The base (100-year) flood elevation from this study is slightly higher (0.4 ft) than the results provided from the scour study at site BFE 1. The HEC-RAS analysis modeled Shoal Creek for more than 9 mi downstream of site BFE 1, considerably farther downstream than the scour study reach, and the difference may be from levee constrictions not modeled in the scour study.

### Base Flood Elevation for Site BFE 3

Site BFE 3 on Shoal Creek Drainage Ditch is located about 2.8 mi downstream from site BFE 2 at County Road 418 and approximately 2.3 mi northeast of Dawn in the southwest part of Livingston County (figs. 1 and 3). Shoal Creek Drainage Ditch flows in a northeasterly direction and is a tributary to the Grand River about 6 mi downstream. In the vicinity of County Road 418, the Shoal Creek Drainage Ditch has a channel-top width of about 110 ft and an average channel depth of 16 ft. The drainage area increases from 566 mi<sup>2</sup> at sites BFE 1 and 2 to 589 mi<sup>2</sup> at site BFE 3. The 100-year recurrence-interval discharge computed using the regression equation from Alexander and Wilson (1995) estimates a base (100-year) flood of 37,500 ft<sup>3</sup>/s (table 2).

The base (100-year) flood elevation for site BFE 3 is 696.5 ft (table 2). Twelve cross sections were used in the HEC-RAS analyses. Cross sections immediately upstream and downstream from County Road 418 were obtained by field (transit-stadia) survey at or near BFE 3 (fig. 3). Other cross sections were obtained by contouring 30-m (98.4-ft) DEM data at a 1-m (3.28-ft) contour interval and cutting cross sections on the contoured surface. These cross sections were then modified based on field surveys and channel data obtained

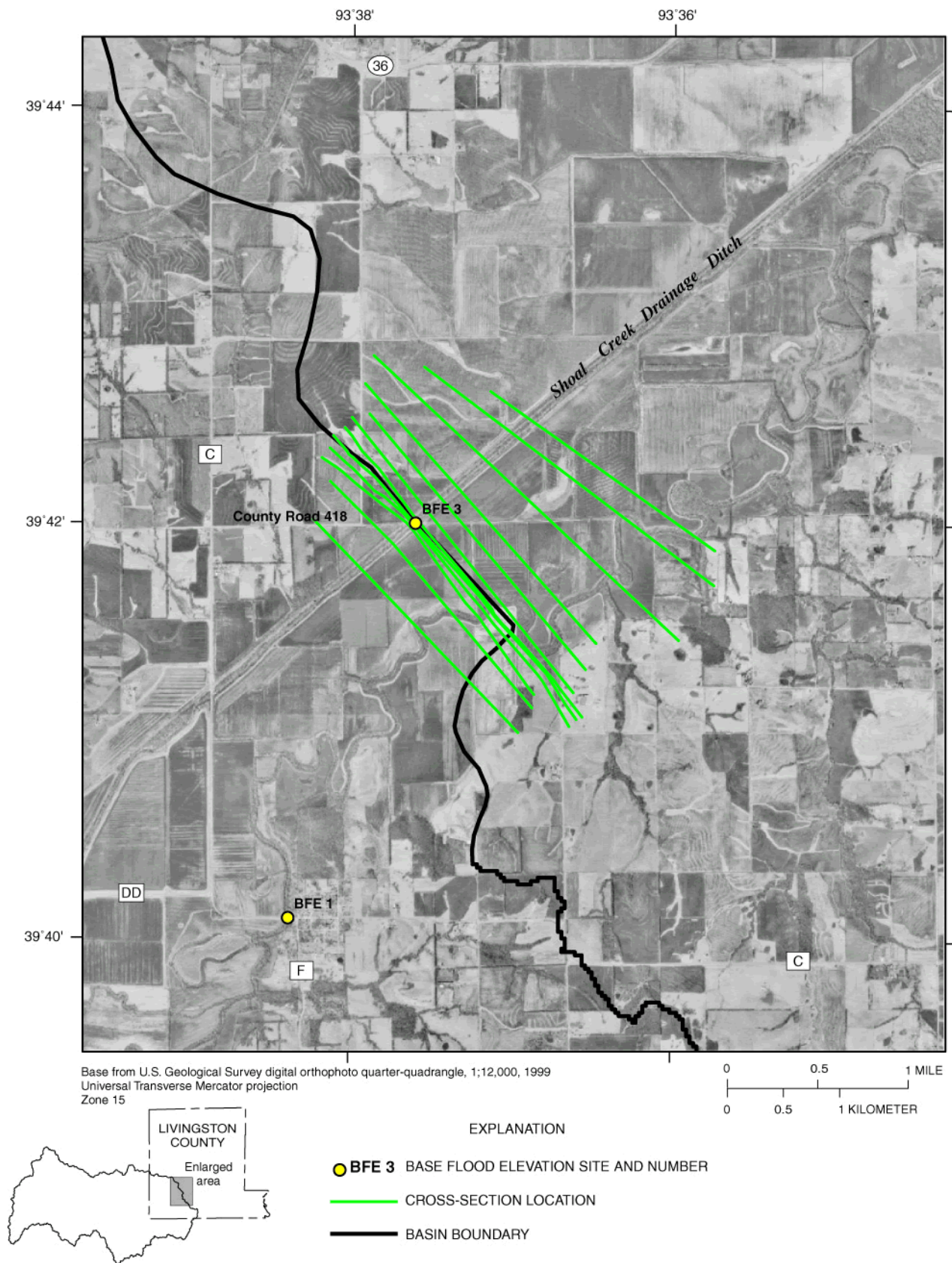
during the site visit. Pertinent bridge and embankment geometry of the piers, wingwalls, abutment and embankment slopes, and road profile were obtained from the field survey. Manning's roughness coefficients used in the HEC-RAS analyses were determined from field observations (Arcement and Schneider, 1989) and ranged from 0.050 to 0.060 for the main channel and from 0.060 to 0.080 for the floodplain. The starting water-surface elevation was determined by normal-depth computation and from HEC-RAS convergence analyses.

### Base Flood Elevation for Site BFE 4

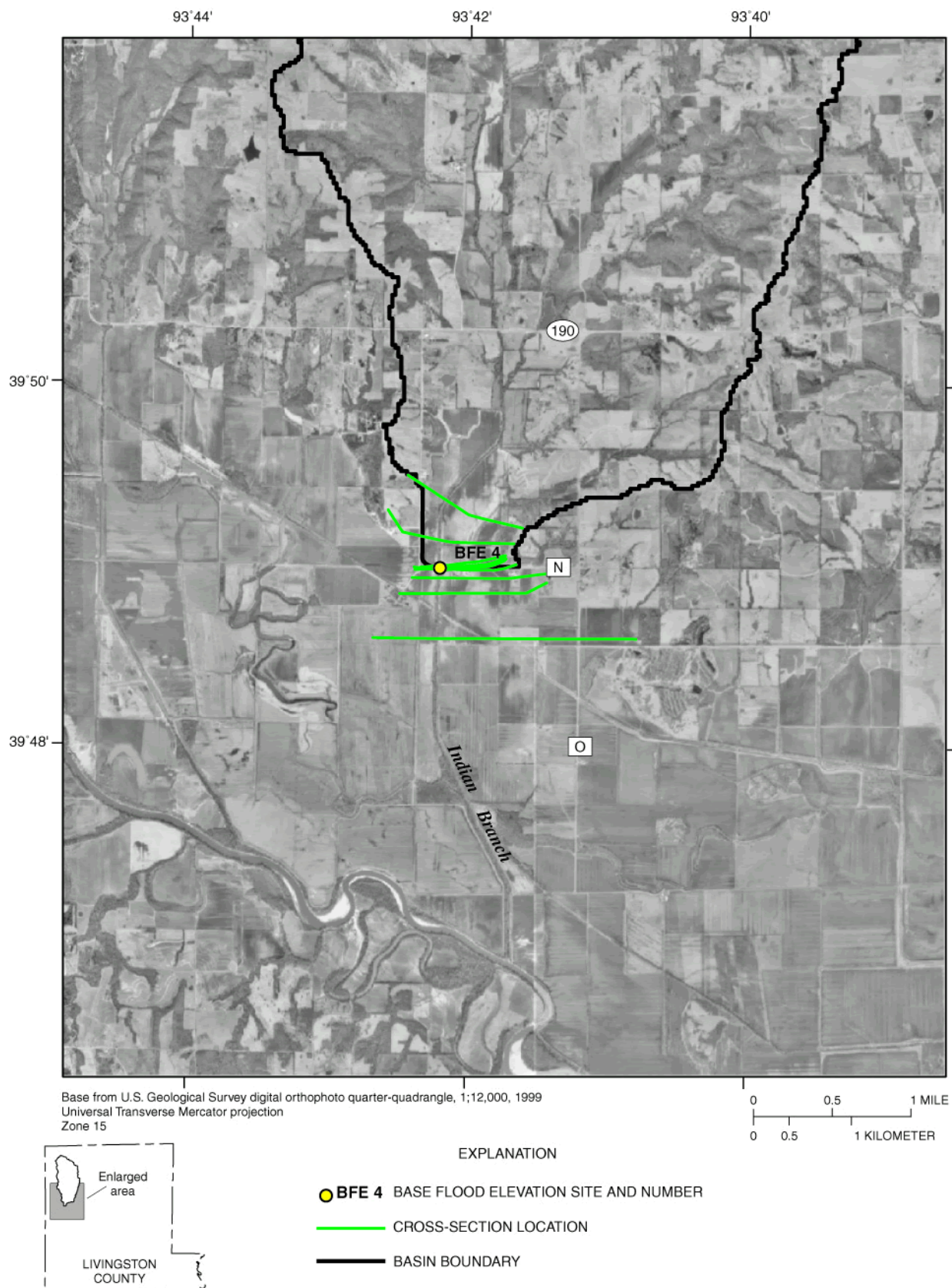
Site BFE 4 on Indian Branch is located on State Highway N and approximately 0.9 mi west of Sampsel in the west-central part of Livingston County (figs. 1 and 4). Indian Branch flows in a southerly direction at site BFE 4. In the vicinity of the road crossing, Indian Branch has a channel-top width of about 45 ft and an average channel depth of 11 ft. The 22.6-mi<sup>2</sup> drainage basin upstream from site BFE 4 predominately is rural farmland. The 100-year recurrence-interval discharge computed using the regression equation from Alexander and Wilson (1995) estimates a base (100-year) flood of 6,990 ft<sup>3</sup>/s (table 2).

The base (100-year) flood elevation for site BFE 4 is 711.7 ft (table 2). Nine cross sections were used in the HEC-RAS analyses. Cross sections immediately upstream and downstream from State Highway N were obtained by field (transit-stadia) survey at or near BFE 4 (fig. 4). Other cross sections were obtained by contouring 30-m (98.4-ft) DEM data at a 1-m (3.28-ft) contour interval and cutting cross sections on the contoured surface. These cross sections were then modified based on field surveys and channel data obtained during the site visit. Pertinent bridge and embankment geometry of piers, wingwalls, abutment and embankment slopes, and road profile were obtained from the field survey. Manning's roughness coefficients used in the HEC-RAS analyses were determined from field observations (Arcement and Schneider, 1989) and ranged from 0.055 to 0.070 for the main channel and from 0.070 to 0.080 for the floodplain. The starting water-surface elevation was determined by normal-depth computation and from HEC-RAS convergence analyses.





**Figure 3.** Shoal Creek Drainage Ditch base (100-year) flood elevation site (BFE 3) near Dawn, Missouri.



**Figure 4.** Indian Branch base (100-year) flood elevation site (BFE 4) at Sampsel, Missouri.



## Base Flood Elevation for Site BFE 5

Site BFE 5 is located on County Road 515 on a tributary to Indian Branch and approximately 4.0 mi north of Sampsel in the northwest part of Livingston County (figs. 1 and 5). The tributary to Indian Branch flows through a concrete culvert in a general southwesterly direction at site BFE 5. The confluence with Indian Branch is less than 0.2 mi downstream. The study reach for site BFE 5 was extended downstream of the confluence to account for any possible backwater effects from Indian Branch. In the vicinity of the road crossing, the tributary to Indian Branch has a channel-top width of about 30 ft and an average channel depth of 7 ft. The 2.50-mi<sup>2</sup> drainage basin upstream from site BFE 5 predominately is rural farmland. The 100-year recurrence-interval discharge computed using the regression equation from Alexander and Wilson (1995) estimates a base (100-year) flood of 2,860 ft<sup>3</sup>/s (table 2).

The base (100-year) flood elevation for site BFE 5 is 755.4 ft (table 2). Sixteen cross sections were used in the HEC-RAS analyses. Cross sections immediately upstream and downstream from County Road 515 were obtained by field (transit-stadia) survey at or near BFE 5 (fig. 5). Other cross sections were obtained by contouring 30-m (98.4-ft) DEM data at a 1-m (3.28-ft) contour interval and cutting cross sections on the contoured surface. These cross sections were then modified based on field surveys and channel data obtained during the site visit. Manning's roughness coefficients used in the HEC-RAS analyses were determined from field observations (Arcement and Schneider, 1989) and ranged from 0.060 to 0.080 for the main channel and from 0.060 to 0.100 for the floodplain. The starting water-surface elevation was determined by normal-depth computation and from HEC-RAS convergence analyses.

## Base Flood Elevation for Site BFE 6

Site BFE 6 on Honey Creek is located on County Road 202 and approximately 1.5 mi southwest of Farmersville in the north-central part of Livingston County (figs. 1 and 6). Honey Creek flows in a general southerly direction at site BFE 6. In the vicinity of the road crossing, Honey Creek has a channel-top width of about 90 ft and an average channel depth of 10 ft. The 106-mi<sup>2</sup> drainage basin upstream from site BFE 6 predominately is rural farmland. The 100-year recurrence-

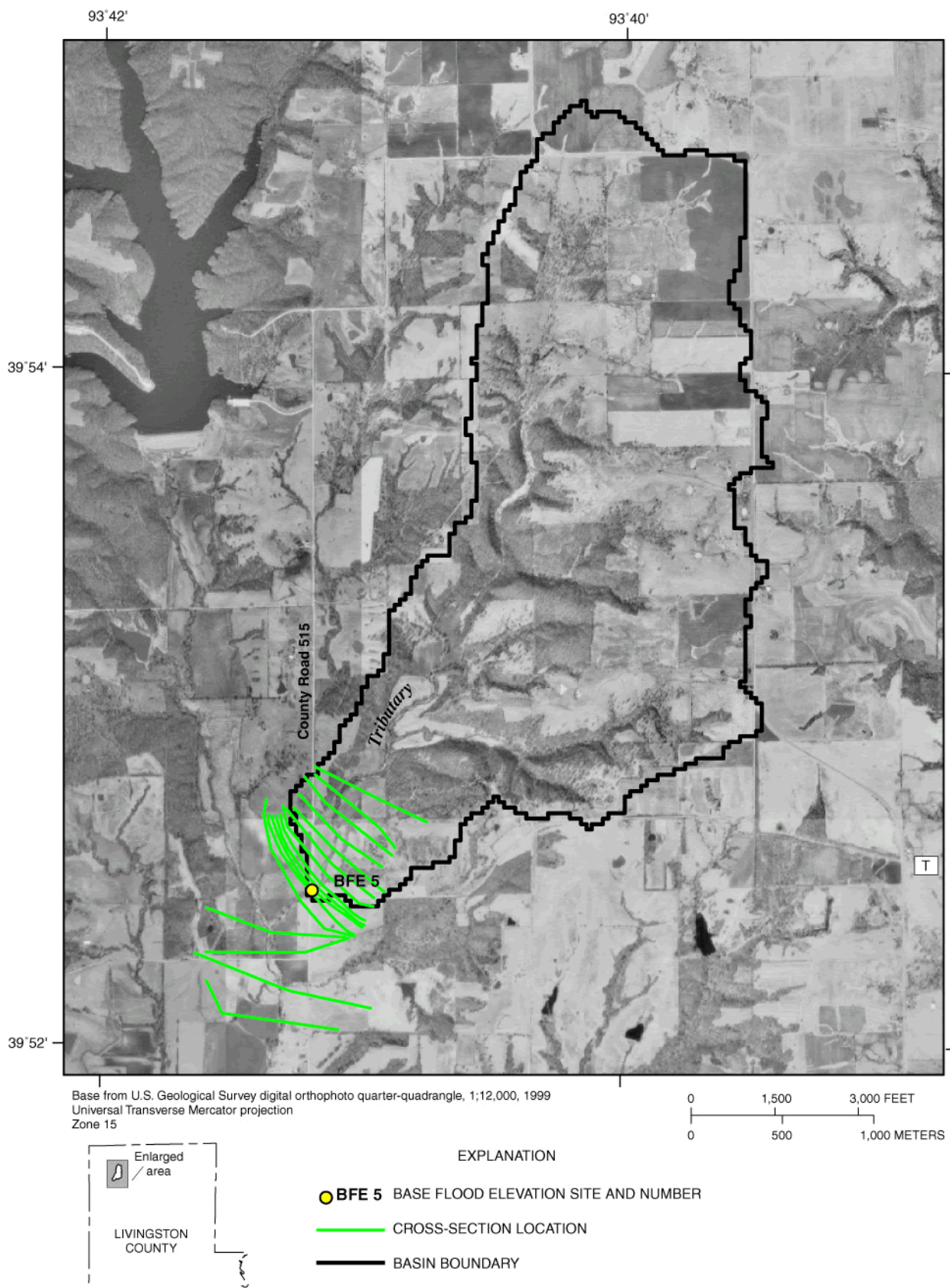
interval discharge computed using the regression equation from Alexander and Wilson (1995) estimates a base (100-year) flood of 15,400 ft<sup>3</sup>/s (table 2).

The base (100-year) flood elevation for site BFE 6 is 730.8 ft (table 2). Eleven cross sections were used in the HEC-RAS analyses. Cross sections immediately upstream and downstream from County Road 202 were obtained by field (transit-stadia) survey at or near BFE 6 (fig. 6). Other cross sections were obtained by contouring 30-m (98.4-ft) DEM data at a 1-m (3.28-ft) contour interval and cutting cross sections on the contoured surface. These cross sections were then modified based on field surveys and channel data obtained during the site visit. Pertinent bridge and embankment geometry of piers, wingwalls, abutment and embankment slopes, and road profile were obtained from the field survey. Manning's roughness coefficients used in the HEC-RAS analyses were determined from field observations (Arcement and Schneider, 1989) and ranged from 0.050 to 0.060 for the main channel and from 0.060 to 0.070 for the floodplain. The starting water-surface elevation was determined by normal-depth computation and from HEC-RAS convergence analyses.

## Base Flood Elevation for Site BFE 7

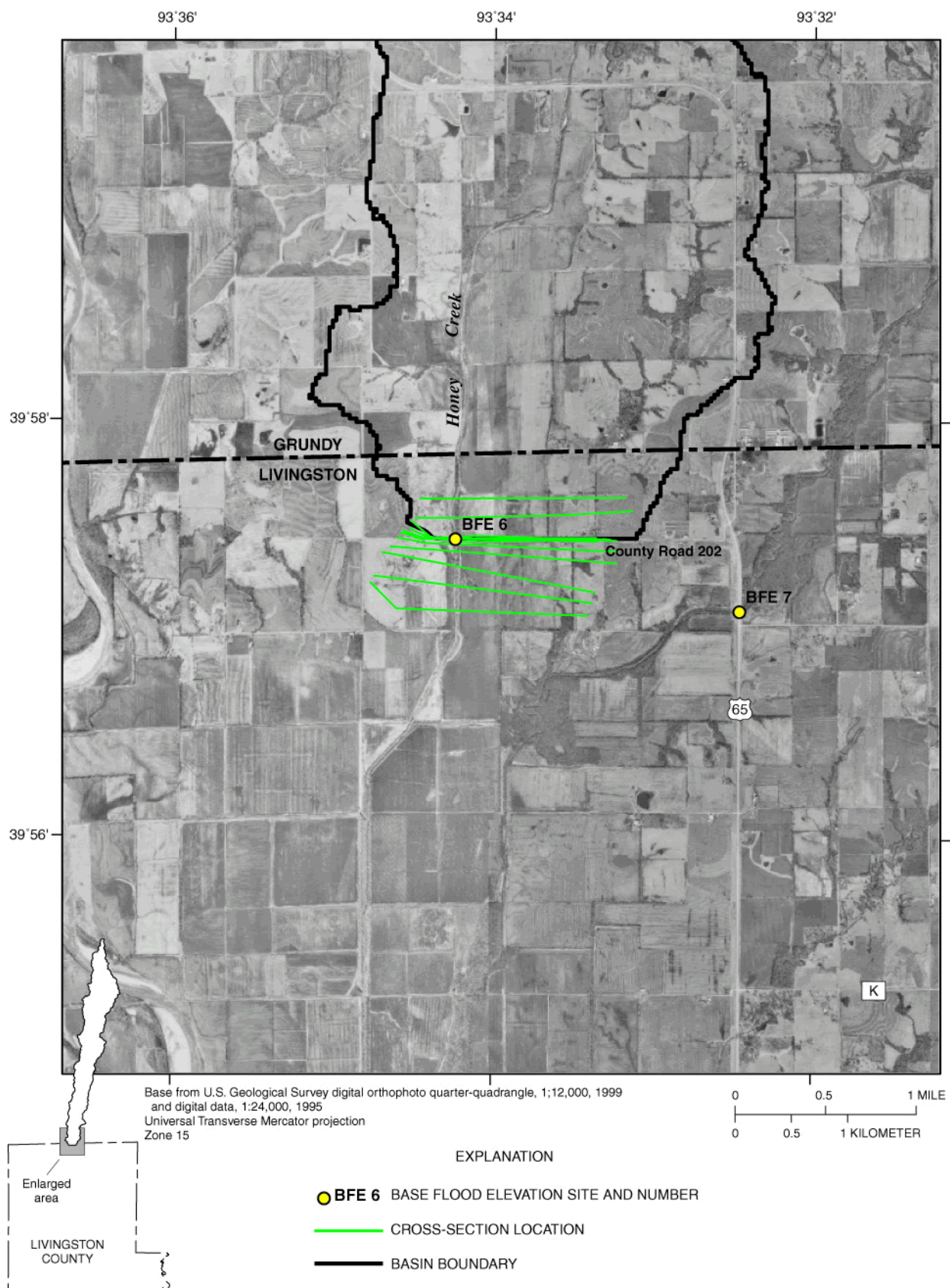
Site BFE 7 on No Creek is located on U.S. Highway 65 and approximately 0.7 mi south of Farmersville in the north-central part of Livingston County (figs. 1 and 7). No Creek flows in a southwesterly direction at site BFE 7. In the vicinity of the road crossing, No Creek has a channel-top width of about 75 ft and an average channel depth of 4 ft. The 67.0-mi<sup>2</sup> drainage basin upstream from site BFE 7 predominately is rural farmland. The 100-year recurrence-interval discharge computed using the regression equation from Alexander and Wilson (1995) estimates a base (100-year) flood of 11,300 ft<sup>3</sup>/s (table 2).

The base (100-year) flood elevation for site BFE 7 is 731.3 ft (table 2; R.J. Huizinga, U.S. Geological Survey, written commun., 2002). Five cross sections were used in the WSPRO analyses. Cross sections immediately upstream and downstream from U.S. Highway 65 were obtained by field (transit-stadia) survey at or near BFE 7 (fig. 7); also, 7.5-minute topographic maps were used to supplement the field survey cross-section data where needed. Pertinent bridge and embankment geometry of piers, wingwalls, abutment and embankment slopes, and road profile were



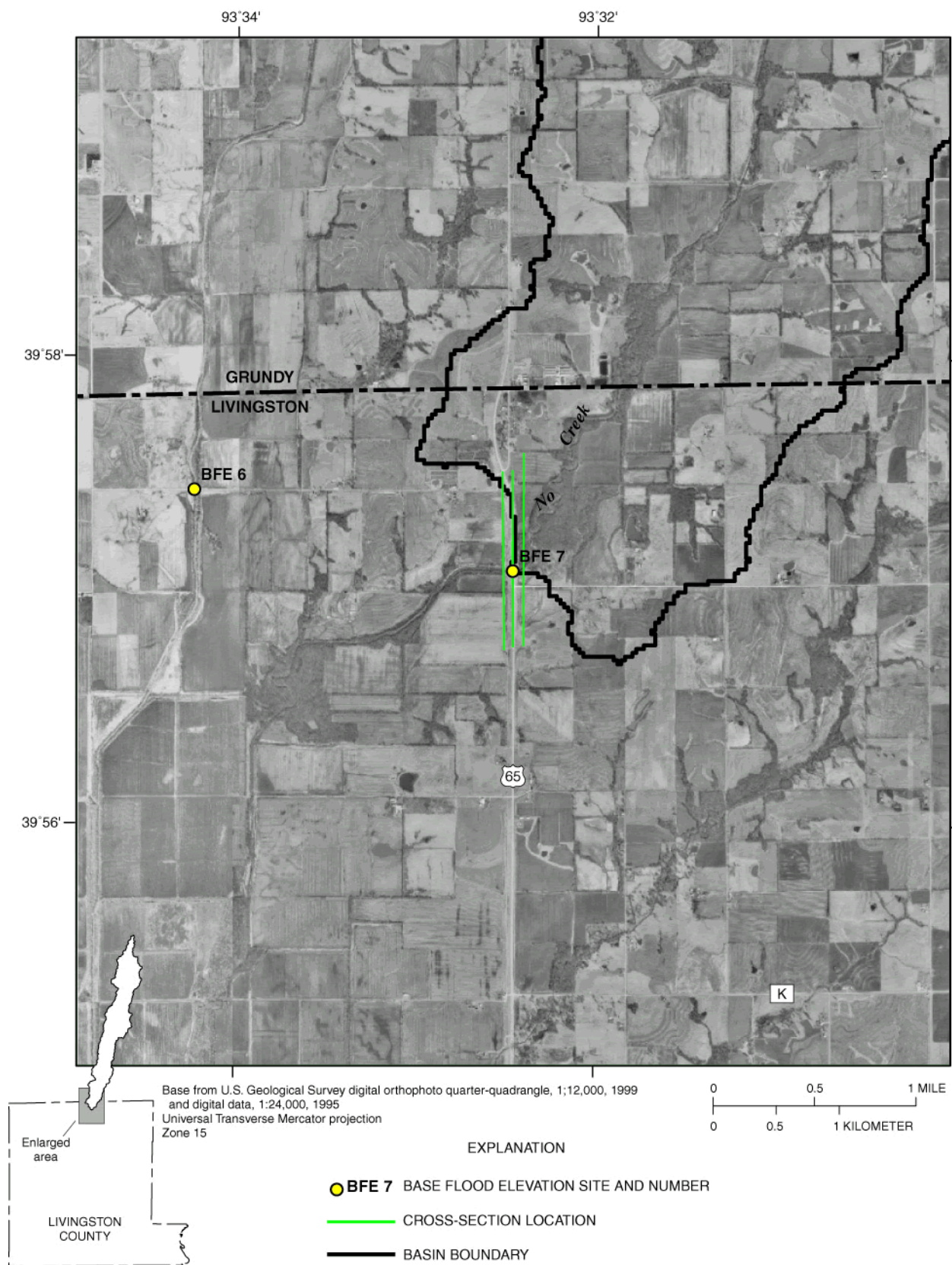
**Figure 5.** Tributary to Indian Branch base (100-year) flood elevation site (BFE 5) near Sampsel, Missouri.





**Figure 6.** Honey Creek base (100-year) flood elevation site (BFE 6) near Farmersville, Missouri.





**Figure 7.** No Creek base (100-year) flood elevation site (BFE 7) near Farmersville, Missouri.

obtained from the field survey. Manning's roughness coefficients used in the WSPRO analyses were determined from field observations (Arcement and Schneider, 1989) and ranged from 0.055 to 0.075 for the main channel and from 0.060 to 0.150 for the floodplain. The starting water-surface elevation was determined by normal-depth computation and from WSPRO convergence analyses.

### **Base Flood Elevation for Site BFE 8**

Site BFE 8 on Crooked Creek is located on U.S. Highway 65 and approximately 4.5 mi north of Chillicothe in the north-central part of Livingston County (figs. 1 and 8). Crooked Creek flows in a westerly direction at site BFE 8. In the vicinity of the road crossing, Crooked Creek has a channel-top width of about 52 ft and an average channel depth of 4 ft. The 13.6-mi<sup>2</sup> drainage basin upstream from site BFE 8 predominately is rural farmland. The 100-year recurrence-interval discharge computed using the regression equation from Alexander and Wilson (1995) estimates a base (100-year) flood of 5,450 ft<sup>3</sup>/s (table 2).

The base (100-year) flood elevation for site BFE 8 is 716.4 ft (table 2; R.J. Huizinga, U.S. Geological Survey, written commun., 2002). Five cross sections were used in the WSPRO analyses. Cross sections immediately upstream and downstream from U.S. Highway 65 were obtained by field (transit-stadia) survey at or near BFE 8 (fig. 8); also, 7.5-minute topographic maps were used to supplement the field survey cross-section data where needed. Pertinent bridge and embankment geometry of piers, wingwalls, abutment and embankment slopes, and road profile were obtained from the field survey. Manning's roughness coefficients used in the WSPRO analyses were determined from field observations (Arcement and Schneider, 1989) and ranged from 0.050 to 0.065 for the main channel and from 0.080 to 0.200 for the floodplain. The starting water-surface elevation was determined by normal-depth computation and from WSPRO convergence analyses.

### **Base Flood Elevation for Site BFE 9**

Site BFE 9 on a tributary to Coon Creek is located on State Highway 190 and at the northwest edge of Chillicothe in the central part of Livingston County (figs. 1 and 9). The tributary to Coon Creek

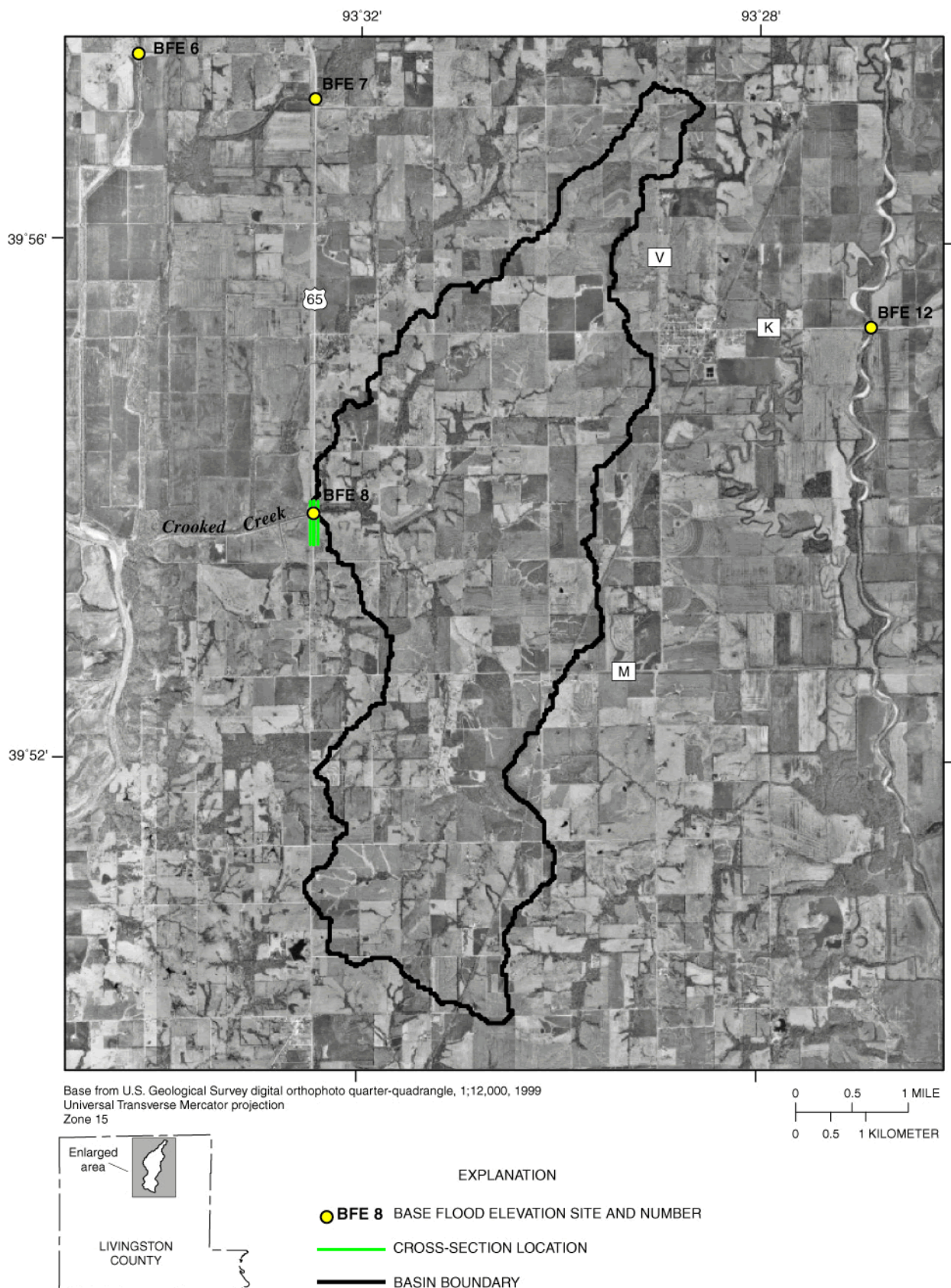
flows through a concrete culvert in a southerly direction at site BFE 9. In the vicinity of the road crossing, the tributary to Coon Creek has a channel-top width of about 18 ft and an average channel depth of 6 ft. The 2.20-mi<sup>2</sup> drainage basin upstream from site BFE 9 predominately is rural farmland. The 100-year recurrence-interval discharge computed using the regression equation from Alexander and Wilson (1995) estimates a base (100-year) flood of 2,080 ft<sup>3</sup>/s (table 2).

The base (100-year) flood elevation for site BFE 9 is 734.9 ft (table 2). Eleven cross sections were used in the HEC-RAS analyses. Cross sections immediately upstream and downstream from State Highway 190 were obtained by field (transit-stadia) survey at or near BFE 9 (fig. 9). Other cross sections were obtained by contouring 30-m (98.4-ft) DEM data at a 1-m (3.28-ft) contour interval and cutting cross sections on the contoured surface. These cross sections were then modified based on field surveys and channel data obtained during the site visit. Pertinent bridge and embankment geometry of piers, wingwalls, abutment and embankment slopes, and road profile were obtained from the field survey. Manning's roughness coefficients used in the HEC-RAS analyses were determined from field observations (Arcement and Schneider, 1989) and ranged from 0.060 to 0.075 for the main channel and from 0.070 to 0.100 for the floodplain. The starting water-surface elevation was determined by normal-depth computation and from HEC-RAS convergence analyses.

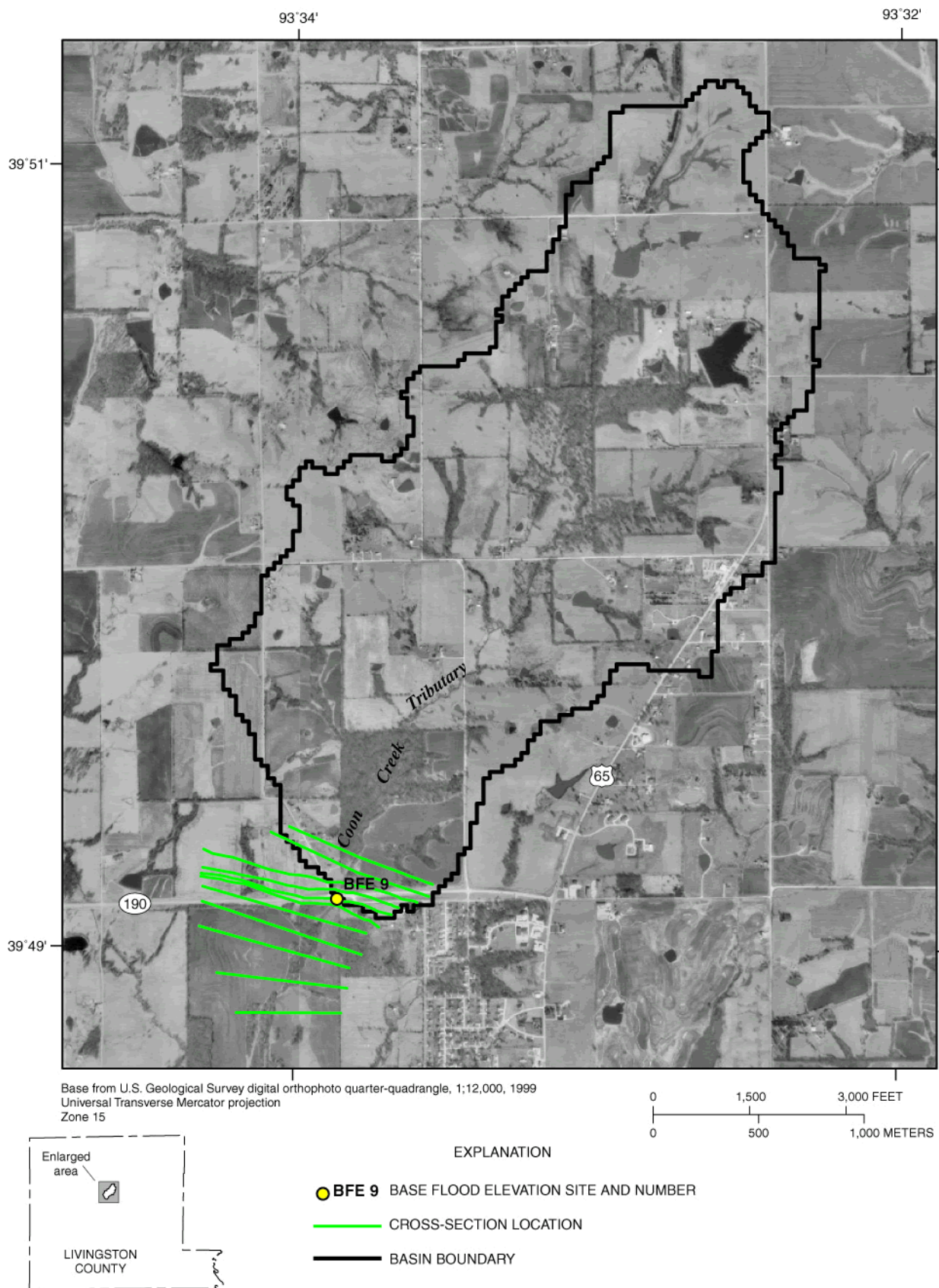
### **Base Flood Elevation for Site BFE 10**

Site BFE 10 on Blackwell Branch is located on County Road 232 and approximately 0.7 mi northeast of Chillicothe in the central part of Livingston County (figs. 1 and 10). Blackwell Branch flows in a south-westerly direction at site BFE 10. At the time of the site visit (June 2002), bridge construction was underway at the crossing, thus a composite valley section was used to model the effect of County Road 232 embankments. In the vicinity of the road crossing, Blackwell Branch has a channel-top width of about 20 ft and an average channel depth of 5 ft. The 3.43-mi<sup>2</sup> drainage basin upstream from site BFE 10 predominately is rural farmland. The 100-year recurrence-interval discharge computed using the regression equation from Alexander and Wilson (1995) estimates a base (100-year) flood of 2,660 ft<sup>3</sup>/s (table 2).



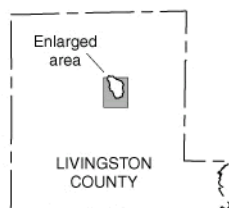
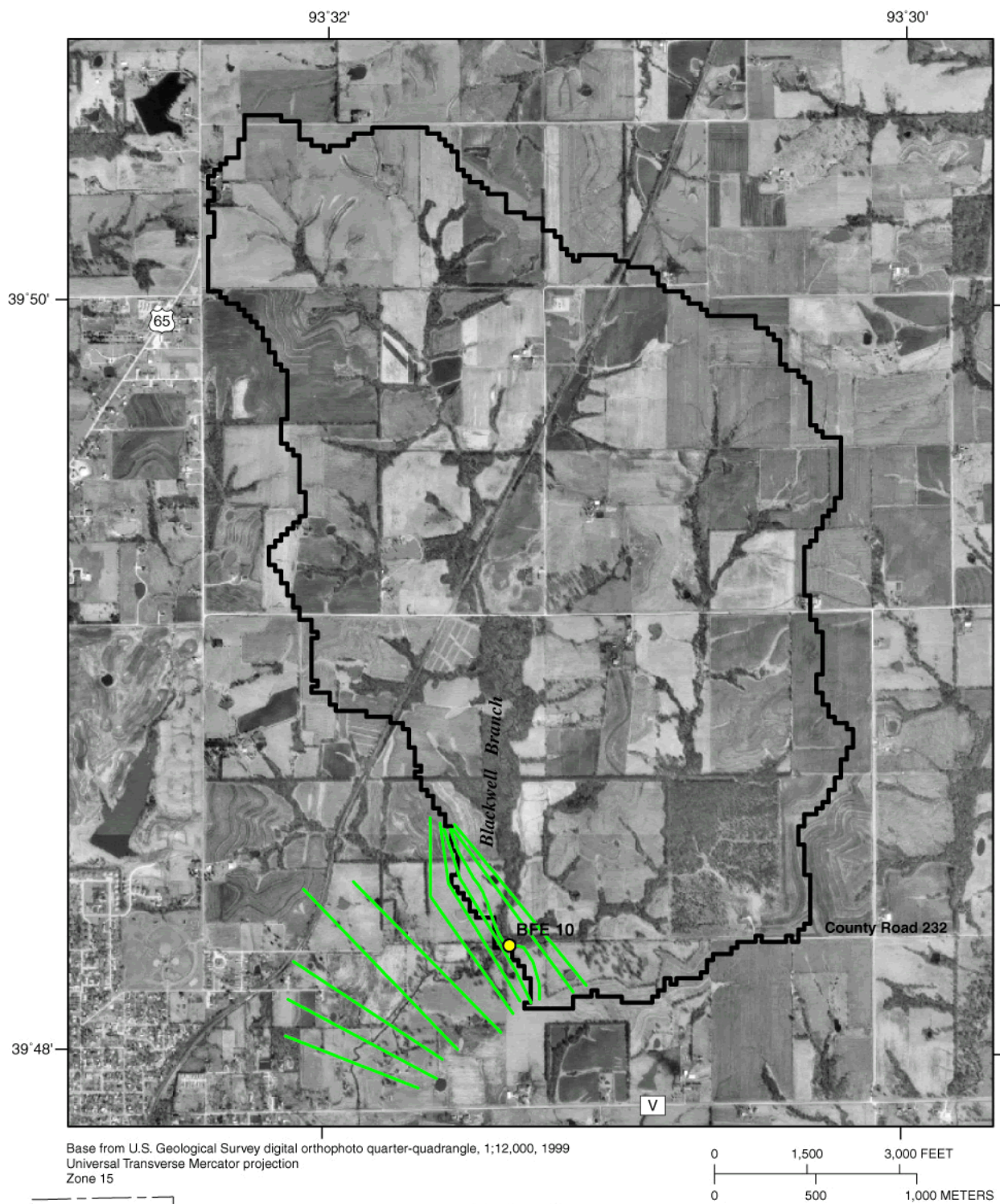


**Figure 8.** Crooked Creek base (100-year) flood elevation site (BFE 8) near Chillicothe, Missouri.



**Figure 9.** Tributary to Coon Creek base (100-year) flood elevation site (BFE 9) at Chillicothe, Missouri.





#### EXPLANATION

- BFE 10 BASE FLOOD ELEVATION SITE AND NUMBER
- CROSS-SECTION LOCATION
- BASIN BOUNDARY

**Figure 10.** Blackwell Branch base (100-year) flood elevation site (BFE 10) at Chillicothe, Missouri.

The base (100-year) flood elevation for site BFE 10 is 738.9 ft (table 2). Eleven cross sections were used in the HEC-RAS analyses. Cross sections immediately upstream and downstream from County Road 232 were obtained by field (transit-stadia) survey at or near site BFE 10 (fig. 10). Other cross sections were obtained by contouring 30-m (98.4-ft) DEM data at a 1-m (3.28-ft) contour interval and cutting cross sections on the contoured surface. These cross sections were then modified based on field surveys and channel data obtained during the site visit. Manning's roughness coefficients used in the HEC-RAS analyses were determined from field observations (Arcement and Schneider, 1989) and ranged from 0.060 to 0.075 for the main channel and from 0.080 to 0.100 for the floodplain. The starting water-surface elevation was determined by normal-depth computation and from HEC-RAS convergence analyses.

### Base Flood Elevation for Site BFE 11

Site BFE 11 on Blackwell Branch is located on U.S. Highway 36 and at the southeast edge of Chillicothe in the central part of Livingston County (figs. 1 and 11). Blackwell Branch flows in a southerly direction at site BFE 11. In the vicinity of the road crossing, Blackwell Branch has a channel-top width of about 50 ft and an average channel depth of 6 ft. The 7.37-mi<sup>2</sup> drainage basin upstream from site BFE 11 predominately is rural farmland. The 100-year recurrence-interval discharge computed using the regression equation from Alexander and Wilson (1995) estimates a base (100-year) flood of 3,790 ft<sup>3</sup>/s (table 2).

The base (100-year) flood elevation for site BFE 11 is 701.7 ft (table 2; R.J. Huizinga, U.S. Geological Survey, written commun., 2002). Five cross sections were used in the WSPRO analyses. Cross sections immediately upstream and downstream from U.S. Highway 36 were obtained by field (transit-stadia) survey at or near BFE 11 (fig. 11); also, 7.5-minute topographic maps were used to supplement the field survey cross-section data where needed. Pertinent bridge and embankment geometry of piers, wingwalls, abutment and embankment slopes, and road profile were obtained from the field survey. Manning's roughness coefficients used in the WSPRO analyses were determined from field observations (Arcement and Schneider, 1989) and ranged from 0.045 to 0.065 for the main channel and from 0.050 to 0.072 for the flood-

plain. The starting water-surface elevation was determined by normal-depth computation and from WSPRO convergence analyses.

### Base Flood Elevation for Site BFE 12

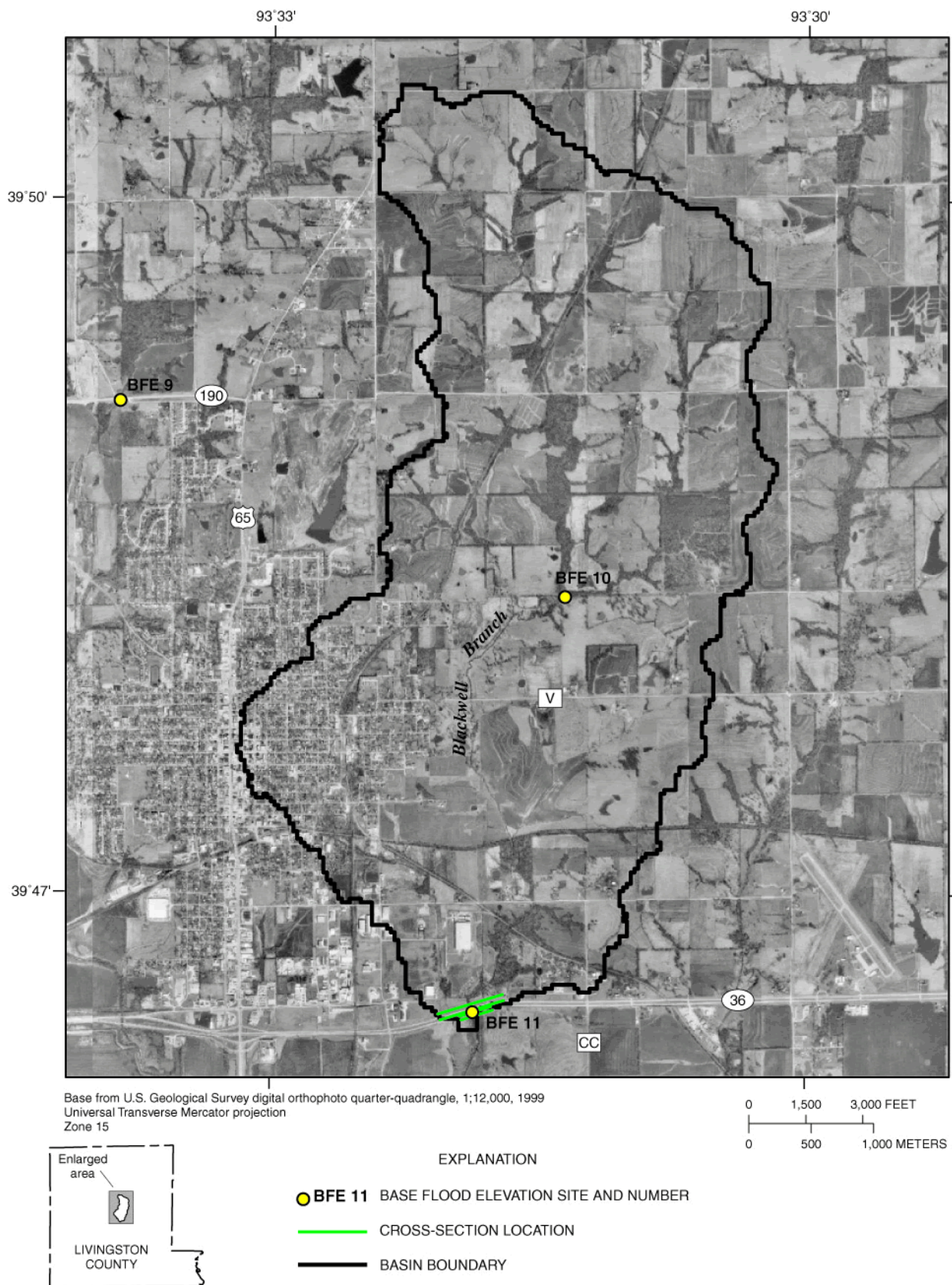
Site BFE 12 on Medicine Creek is located on State Highway K and approximately 1.1 mi east of Chula in the northeast part of Livingston County (figs. 1 and 12). Medicine Creek flows in a southerly direction at site BFE 12. In the vicinity of the road crossing, Medicine Creek has a channel-top width of about 100 ft and an average channel depth of 20 ft. The 395-mi<sup>2</sup> drainage basin upstream from site BFE 12 predominately is rural farmland. The 100-year recurrence-interval discharge computed using the regression equation from Alexander and Wilson (1995) estimates a base (100-year) flood of 30,700 ft<sup>3</sup>/s (table 2).

The base (100-year) flood elevation for site BFE 12 is 721.7 ft (table 2; R.J. Huizinga, U.S. Geological Survey, written commun., 2002). Six cross sections were used in the WSPRO analyses. Cross sections immediately upstream and downstream from State Highway K were obtained by field (transit-stadia) survey at or near BFE 12 (fig. 12); also, 7.5-minute topographic maps were used to supplement the field survey cross-section data where needed. Pertinent bridge and embankment geometry of piers, wingwalls, abutment and embankment slopes, and road profile were obtained from the field survey. Manning's roughness coefficients used in the WSPRO analyses were determined from field observations (Arcement and Schneider, 1989) and were 0.035 for the main channel and ranged from 0.040 to 0.080 for the floodplain. The starting water-surface elevation was determined by normal-depth computation and from WSPRO convergence analyses.

### Base Flood Elevation for Site BFE 13

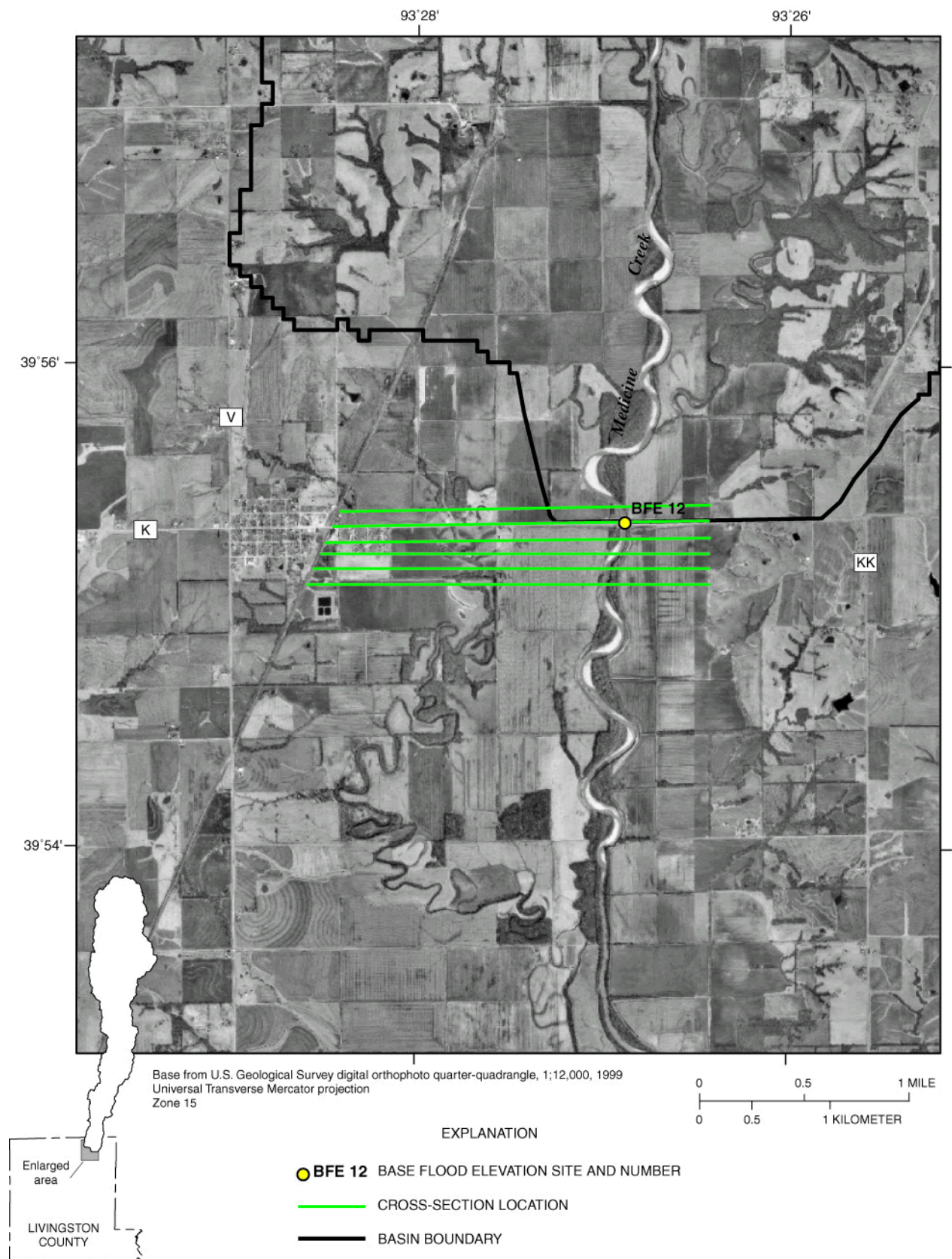
Site BFE 13 on Muddy Creek is located on State Highway KK and approximately 4.5 mi east of Chula in the northeast part of Livingston County (figs. 1 and 13). Muddy Creek flows in a southerly direction at site BFE 13. In the vicinity of the road crossing, Muddy Creek has a channel-top width of about 70 ft and an average channel depth of 12 ft. The 44.3-mi<sup>2</sup> drainage basin upstream from site BFE 13 predominately is rural farmland. The 100-year recurrence-interval discharge





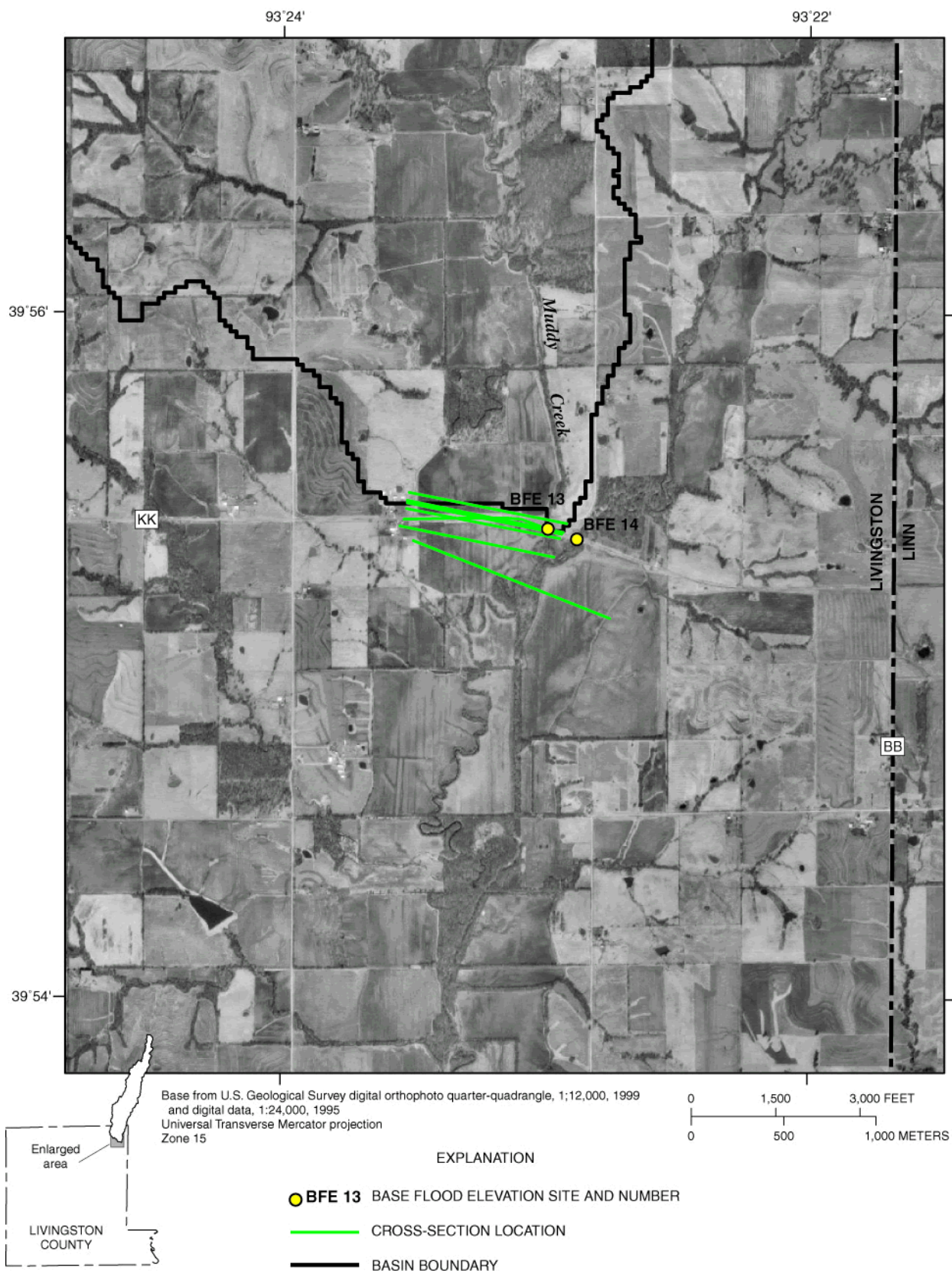
**Figure 11.** Blackwell Branch base (100-year) flood elevation site (BFE 11) at Chillicothe, Missouri.





**Figure 12.** Medicine Creek base (100-year) flood elevation site (BFE 12) near Chula, Missouri.





**Figure 13.** Muddy Creek base (100-year) flood elevation site (BFE 13) near Chula, Missouri.

computed using the regression equation from Alexander and Wilson (1995) estimates a base (100-year) flood of 9,360 ft<sup>3</sup>/s (table 2). WSPRO analyses indicated that the bridge section was not acting as a contracted opening at the 100-year flood discharges; therefore, the State Highway KK bridge and road section were analyzed as a composite valley section.

The base (100-year) flood elevation for site BFE 13 is 733.0 ft (table 2; R.J. Huizinga, U.S. Geological Survey, written commun., 2002). Eight cross sections were used in the WSPRO analyses. Cross sections immediately upstream and downstream from State Highway KK were obtained by field (transit-stadia) survey at or near BFE 13 (fig. 13); also, 7.5-minute topographic maps were used to supplement the field survey cross-section data where needed. Pertinent bridge and embankment geometry of piers, wingwalls, abutment and embankment slopes, and road profile were obtained from the field survey. Manning's roughness coefficients used in the WSPRO analyses were determined from field observations (Arcement and Schneider, 1989) and ranged from 0.055 to 0.065 for the main channel and from 0.045 to 0.055 for the floodplain. The starting water-surface elevation was determined by normal-depth computation and from WSPRO convergence analyses.

### **Base Flood Elevation for Site BFE 14**

Site BFE 14 on Little Muddy Creek is located on State Highway KK and approximately 4.6 mi east of Chula in the northeast part of Livingston County (figs. 1 and 14). Little Muddy Creek is 0.1 mi east of site BFE 13, and site BFE 14 is about 600 ft upstream from the confluence of Little Muddy Creek and Muddy Creek. In the vicinity of the road crossing, Little Muddy Creek has a channel-top width of about 60 ft and an average channel depth of 10 ft. The 19.3-mi<sup>2</sup> drainage basin upstream from site BFE 14 predominately is rural farmland. The 100-year recurrence-interval discharge computed using the regression equation from Alexander and Wilson (1995) estimates a base (100-year) flood of 6,170 ft<sup>3</sup>/s (table 2).

The base (100-year) flood elevation for site BFE 14 is 734.6 ft (table 2; R.J. Huizinga, U.S. Geological Survey, written commun., 2002). Six cross sections were used in the WSPRO analyses. Cross sections immediately upstream and downstream from State Highway KK were obtained by field (transit-stadia) survey at or near BFE 14 (fig. 14); also, 7.5-minute

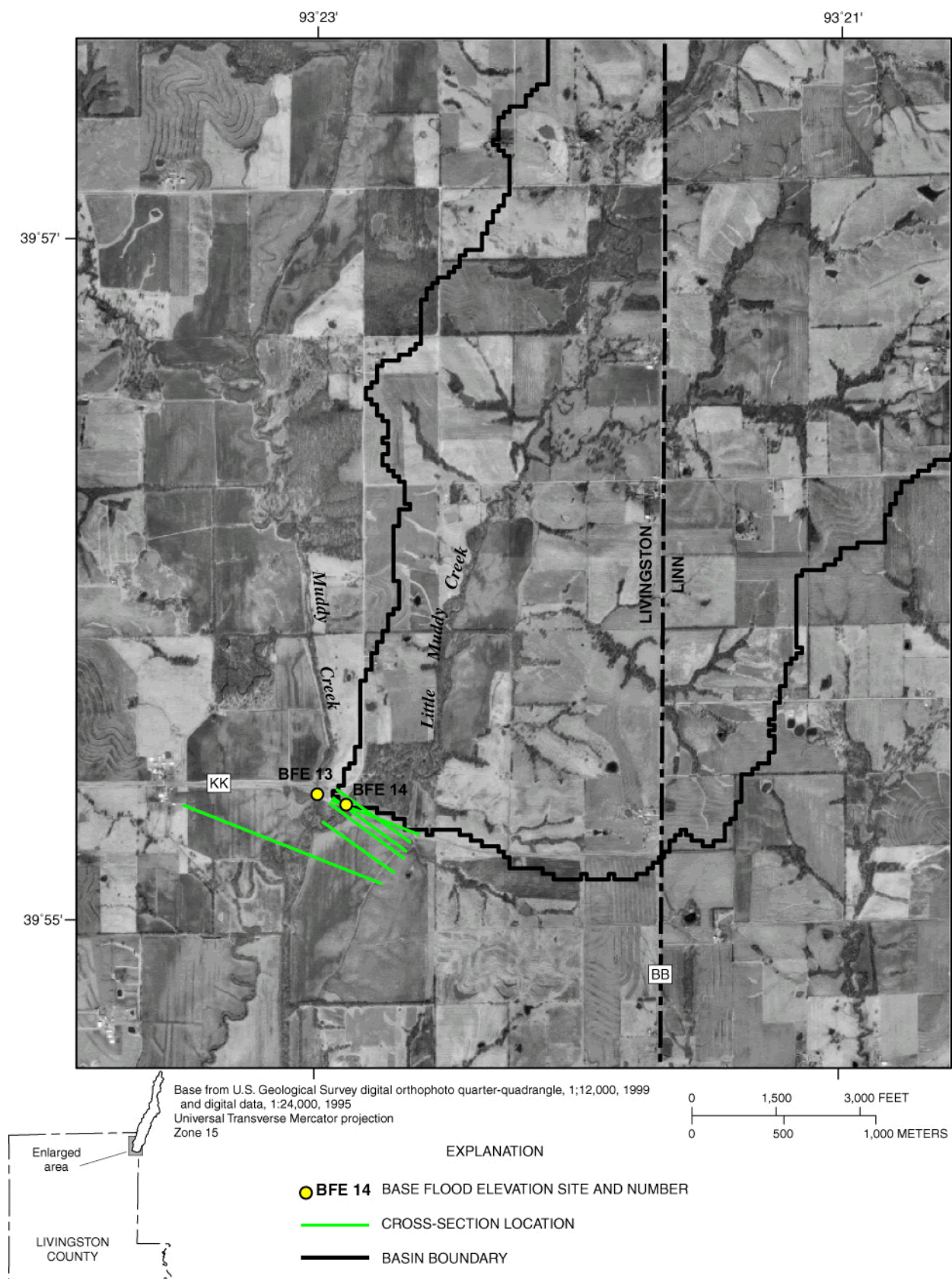
topographic maps were used to supplement the field survey cross-section data where needed. Pertinent bridge and embankment geometry of piers, wingwalls, abutment and embankment slopes, and road profile were obtained from the field survey. Manning's roughness coefficients used in the WSPRO analyses were determined from field observations (Arcement and Schneider, 1989) and ranged from 0.040 to 0.065 for the main channel and from 0.045 to 0.055 for the floodplain. The starting water-surface elevation was determined by normal-depth computation and from WSPRO convergence analyses.

### **Base Flood Elevation for Site BFE 15**

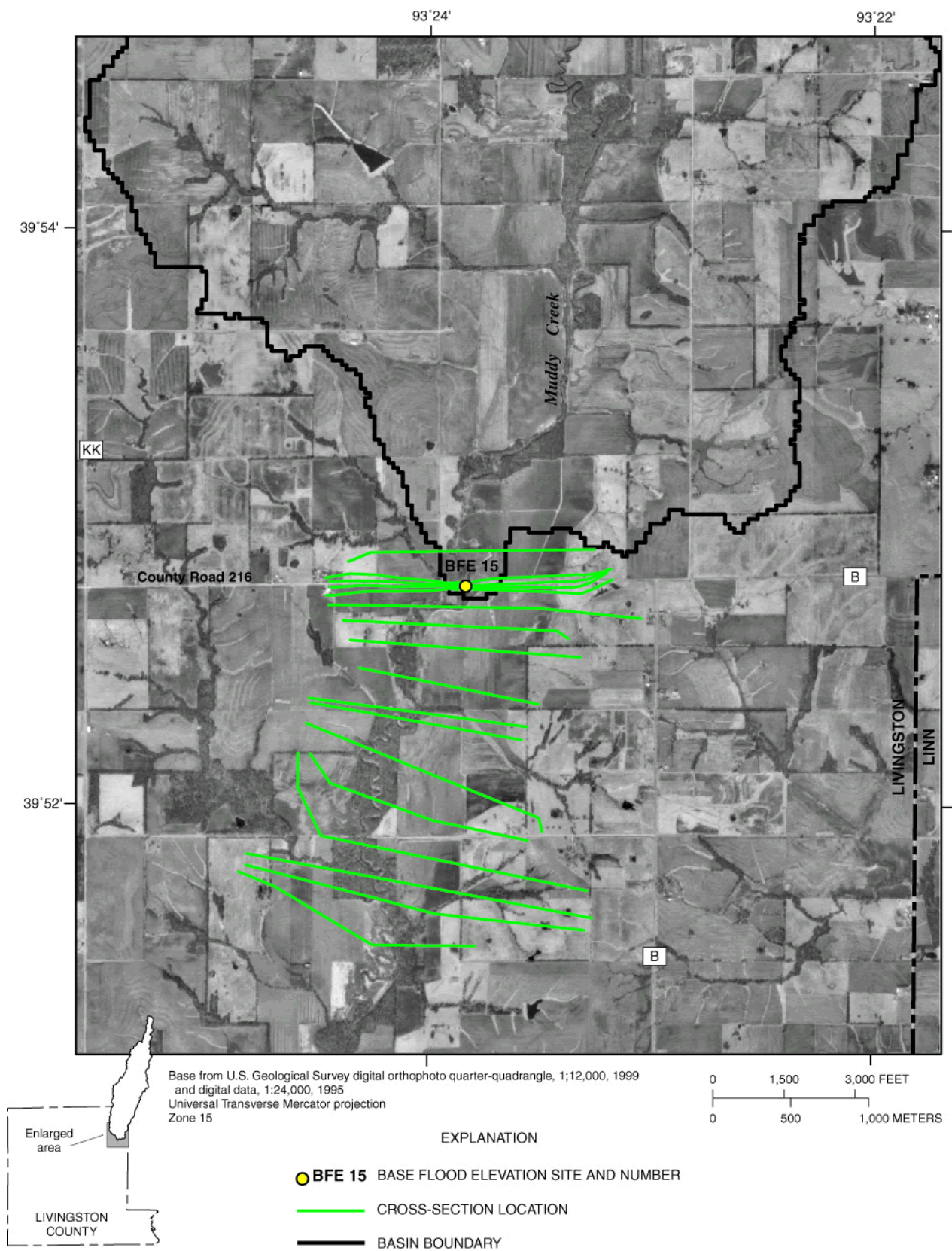
Site BFE 15 on Muddy Creek is located on County Road 216 and approximately 5.0 mi southeast of Chula in the northeast part of Livingston County (figs. 1 and 15). Muddy Creek flows in a southerly direction at site BFE 15. In the vicinity of the road crossing, Muddy Creek has a channel-top width of about 75 ft and an average channel depth of 12 ft. The 72.2-mi<sup>2</sup> drainage basin upstream from site BFE 15 predominately is rural farmland. The 100-year recurrence-interval discharge computed using the regression equation from Alexander and Wilson (1995) estimates a base (100-year) flood of 12,600 ft<sup>3</sup>/s (table 2).

The base (100-year) flood elevation for site BFE 15 is 717.9 ft (table 2). Seventeen cross sections were used in the HEC-RAS analyses. Cross sections immediately upstream and downstream from County Road 216 were obtained by field (transit-stadia) survey at or near BFE 15 (fig. 15). Other cross sections were obtained by contouring 30-m (98.4-ft) DEM data at a 1-m (3.28-ft) contour interval and cutting cross sections on the contoured surface. These cross sections were then modified based on field surveys and channel data obtained during the site visit. Pertinent bridge and embankment geometry of piers, wingwalls, abutment and embankment slopes, and road profile were obtained from the field survey. Manning's roughness coefficients used in the HEC-RAS analyses were determined from field observations (Arcement and Schneider, 1989) and ranged from 0.050 to 0.090 for the main channel and from 0.070 to 0.100 for the floodplain. The starting water-surface elevation was determined by normal-depth computation and from HEC-RAS convergence analyses.





**Figure 14.** Little Muddy Creek base (100-year) flood elevation site (BFE 14) near Chula, Missouri.



**Figure 15.** Muddy Creek base (100-year) flood elevation site (BFE 15) near Chula, Missouri.



## Base Flood Elevation for Site BFE 16

Site BFE 16 on Medicine Creek is located on U.S. Highway 36 and approximately 2.0 mi southwest of Wheeling in the east-central part of Livingston County (figs. 1 and 16). Medicine Creek flows in a southerly direction at site BFE 16. In the vicinity of the road crossing, Medicine Creek has a channel-top width of about 200 ft and an average channel depth of 12 ft. The 520-mi<sup>2</sup> drainage basin upstream from site BFE 16 predominately is rural farmland. The 100-year recurrence-interval discharge computed using the regression equation from Alexander and Wilson (1995) estimates a base (100-year) flood of 37,000 ft<sup>3</sup>/s (table 2).

The base (100-year) flood elevation for site BFE 16 is 686.1 ft (table 2). Ten cross sections were used in the HEC-RAS analyses. Cross sections immediately upstream and downstream from U.S. Highway 36 were obtained by field (transit-stadia) survey at or near BFE 16 (fig. 16). Other cross sections were obtained by contouring 30-m (98.4-ft) DEM data at a 1-m (3.28-ft) contour interval and cutting cross sections on the contoured surface. These cross sections were then modified based on field surveys and channel data obtained during the site visit. Pertinent bridge and embankment geometry of piers, wingwalls, abutment and embankment slopes, and road profile were obtained from the field survey. Manning's roughness coefficients used in the HEC-RAS analyses were determined from field observations (Arcement and Schneider, 1989) and ranged from 0.050 to 0.070 for the main channel and from 0.070 to 0.080 for the floodplain. The starting water-surface elevation was determined by normal-depth computation and from HEC-RAS convergence analyses.

## Base Flood Elevation for Site BFE 17

Site BFE 17 on Campbell Creek is located on County Road 310 and approximately 2.1 mi southwest of Bedford in the southeast part of Livingston County (figs. 1 and 17). Campbell Creek flows in a northeasterly direction at site BFE 17. In the vicinity of the road crossing, Campbell Creek has a channel-top width of about 40 ft and an average channel depth of 7 ft. The 4.19-mi<sup>2</sup> drainage basin upstream from site BFE 17 predominately is rural farmland. The 100-year recurrence-interval discharge computed using the regression equation from Alexander and Wilson (1995) estimates a base (100-year) flood of 3,410 ft<sup>3</sup>/s (table 2).

The base (100-year) flood elevation for site BFE 17 is 691.8 ft (table 2). Sixteen cross sections were used in the HEC-RAS analyses. Cross sections immediately upstream and downstream from County Road 310 were obtained by field (transit-stadia) survey at or near BFE 17 (fig. 17). Other cross sections were obtained by contouring 30-m (98.4-ft) DEM data at a 1-m (3.28-ft) contour interval and cutting cross sections on the contoured surface. These cross sections were then modified based on field surveys and channel data obtained during the site visit. Pertinent bridge and embankment geometry of piers, wingwalls, abutment and embankment slopes, and road profile were obtained from the field survey. Manning's roughness coefficients used in the HEC-RAS analyses were determined from field observations (Arcement and Schneider, 1989) and ranged from 0.050 to 0.080 for the main channel and from 0.070 to 0.100 for the floodplain. The starting water-surface elevation was determined by normal-depth computation and from HEC-RAS convergence analyses.

## Base Flood Elevation for Site BFE 18

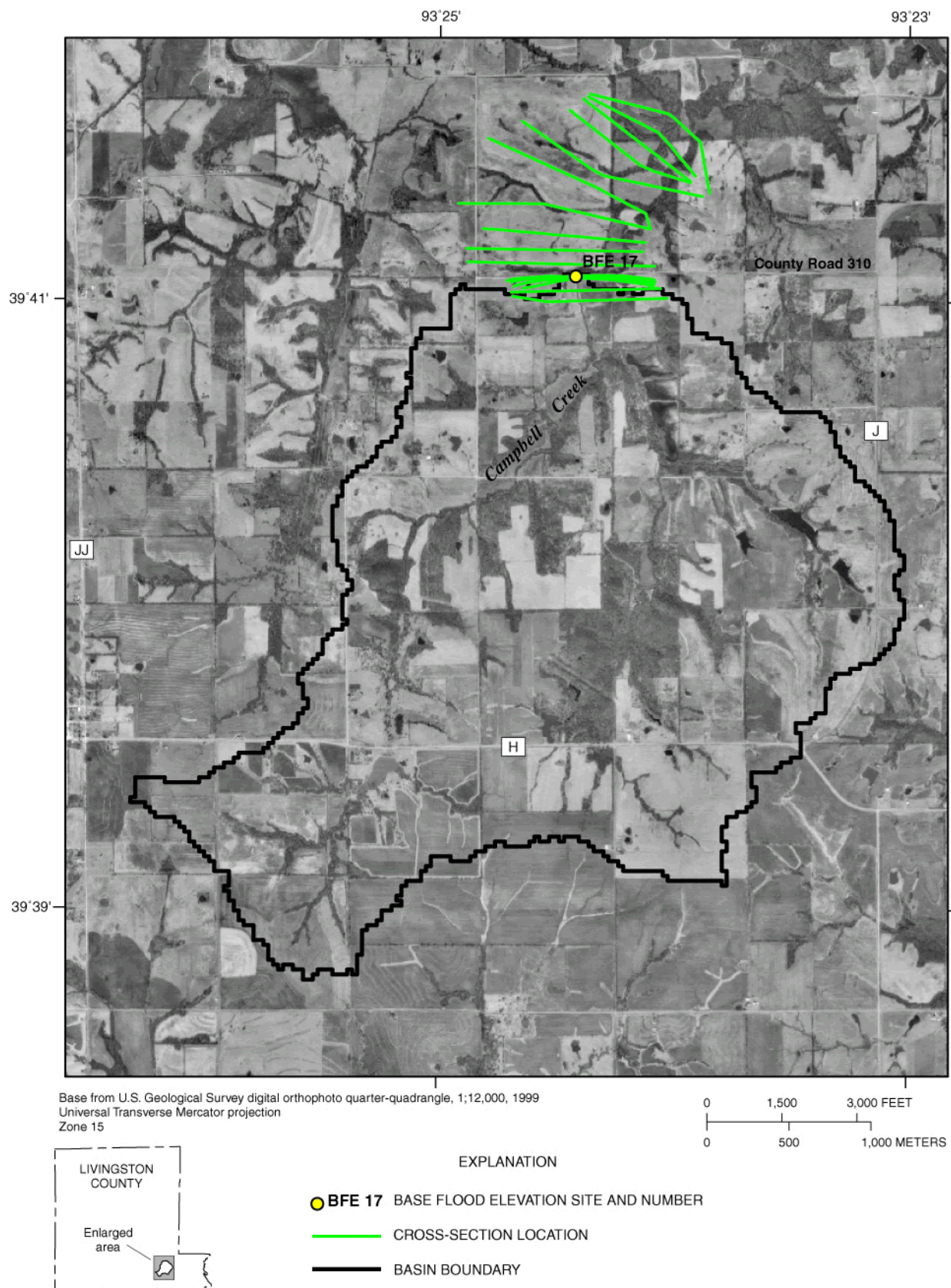
Site BFE 18 on Towstring Creek in the southeast part of Livingston County is located on County Road 387 and approximately 3.0 mi northeast of Hale in Carroll County (figs. 1 and 18). Towstring Creek flows through a concrete culvert in a southeasterly direction at site BFE 18. In the vicinity of the road crossing, Towstring Creek has a channel-top width of about 35 ft and an average channel depth of 8 ft. The 11.4-mi<sup>2</sup> drainage basin upstream from site BFE 18 predominately is rural farmland. The 100-year recurrence-interval discharge computed using the regression equation from Alexander and Wilson (1995) estimates a base (100-year) flood of 5,600 ft<sup>3</sup>/s (table 2).

The base (100-year) flood elevation for site BFE 18 is 667.4 ft (table 2). Twelve cross sections were used in the HEC-RAS analyses. Cross sections immediately upstream and downstream from County Road 387 were obtained by field (transit-stadia) survey at or near BFE 18 (fig. 18). Other cross sections were obtained by contouring 30-m (98.4-ft) DEM data at a 1-m (3.28-ft) contour interval and cutting cross sections on the contoured surface. These cross sections were then modified based on field surveys and channel data obtained during the site visit. Manning's roughness coefficients used in the HEC-RAS analyses were determined from field observations (Arcement and Schneider, 1989) and



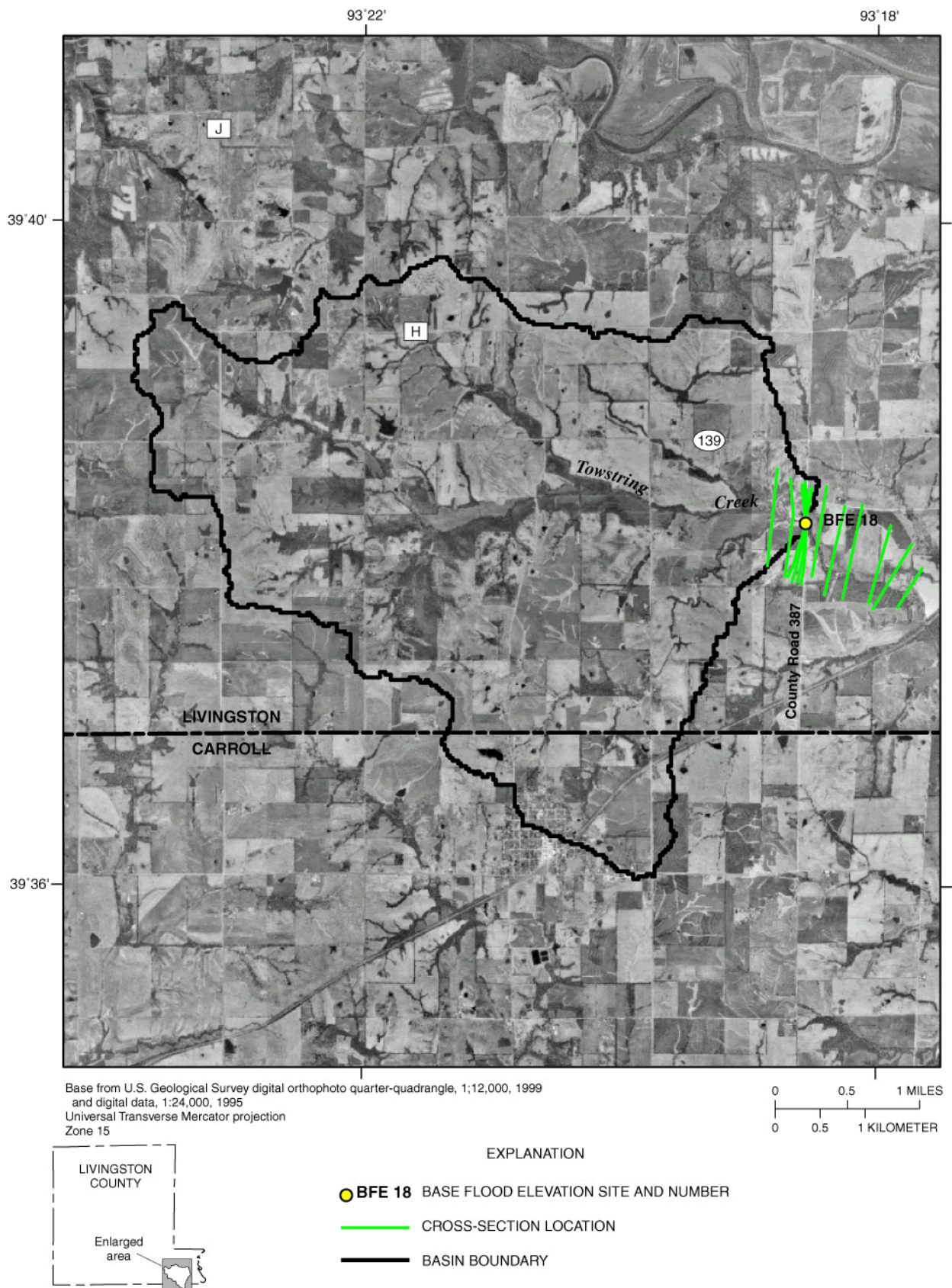
**Figure 16.** Medicine Creek base (100-year) flood elevation site (BFE 16) near Wheeling, Missouri.





**Figure 17.** Campbell Creek base (100-year) flood elevation site (BFE 17) near Bedford, Missouri.





**Figure 18.** Towstring Creek base (100-year) flood elevation site (BFE 18) near Hale, Missouri.



ranged from 0.060 to 0.080 for the main channel and from 0.080 to 0.100 for the floodplain. The starting water-surface elevation was determined by normal-depth computation and from HEC-RAS convergence analyses.

## SUMMARY

The primary criteria for community participation in the National Flood Insurance Program is the adoption and enforcement of floodplain management requirements. The purpose of the requirements is to minimize the potential for flood damages to existing and proposed development in flood-hazard areas. The U.S. Geological Survey, in cooperation with the State Emergency Management Agency, has completed a study using one-dimensional surface-water flow models to compute base (100-year) flood elevations (BFE) for 18 approximate Zone A sites designated by the Federal Emergency Management Agency in Livingston County, Missouri.

The 18 sites are located at U.S., State, or County road crossings, and the base flood elevation for a site was determined on the upstream side of each crossing. The one-dimensional surface-water flow model, HEC-RAS, was used to compute the base flood elevations at sites BFE 1 to 6, 9, 10, and 15 to 18, and Water-Surface Profile (WSPRO) was used at sites BFE 7, 8, and 11 to 14. Three of the 18 BFE sites are located near or at the community of Dawn. Site BFE 1 is located on Shoal Creek at State Highway C, and sites BFE 2 and 3 are located on Shoal Creek Drainage Ditch at State Highway DD and at County Road 418. The base (100-year) water-surface elevations for BFE 1, 2, and 3 are 701.0, 701.0, and 696.5 feet, respectively. Sites BFE 4 and 5 are located near Sampsel, Missouri. Indian Branch at State Highway N at Sampsel is site BFE 4, where the base (100-year) flood elevation is 711.7 feet. A tributary to Indian Branch at County Road 515 near Sampsel is site BFE 5, where the base (100-year) flood elevation is 755.4 feet.

Sites BFE 6, 7, and 8 are located in the north-central part of Livingston County. Site BFE 6 is on Honey Creek at County Road 202 near Farmersville. Two sites (BFE 7 and 8) are located at the U.S. Highway 65 crossings of No Creek near Farmersville and Crooked Creek near Chillicothe, respectively. The base (100-year) flood elevations for BFE 6, 7, and 8 are 730.8, 731.3, and 716.4 feet, respectively.

Three sites are located at Chillicothe (BFE 9, 10, and 11). Northwest of Chillicothe is BFE 9 on a tributary to Coon Creek at State Highway 190. The base (100-year) flood elevation at BFE 9 is 734.9 feet. Two sites are located on Blackwell Branch (BFE 10 and 11). Site BFE 10 is located at County Road 232 and has a base (100-year) flood elevation of 738.9 feet, and BFE 11 is located at U.S. Highway 36 and has a base (100-year) flood elevation of 701.7 feet.

Four sites are located in the northeast part of Livingston County (BFE 12, 13, 14, and 15). Site BFE 12 on Medicine Creek at State Highway K near Chula, Missouri. Sites BFE 13 and 14 are on Muddy Creek and Little Muddy Creek at State Highway KK near Chula. Downstream of site BFE 13 on Muddy Creek is site BFE 15 at County Road 216 near Chula. The base (100-year) flood elevations for BFE 12, 13, 14, and 15 are 721.7, 733.0, 734.6, and 717.9 feet, respectively.

Sites BFE 16, 17, and 18 are located in the east-central and southeast parts of Livingston County. Site BFE 16, in the east-central part of Livingston County, is on Medicine Creek at U.S. Highway 36 near Wheeling. Sites BFE 17 and 18, in the southeast part of Livingston County, are on Campbell Creek at County Road 310 near Bedford and Towstring Creek at County Road 387 near Hale. The base (100-year) flood elevations for BFE 16, 17, and 18 are 686.1, 691.8, and 667.4 feet, respectively.

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## SUPPLEMENTAL DATA

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**Table 1.** Reference mark elevations and locations for selected sites in Livingston County, Missouri  
[ft, feet; NGVD 29, National Geodetic Vertical Datum of 1929]

Reference mark number	Reference mark elevation <sup>a</sup> (ft)	Description of location
RM 1–BFE 1	703.59	Cut square on top of northeast concrete wingwall of State Highway C bridge over Shoal Creek at Dawn.
RM 1–BFE 2	706.22	Cut square on top of northeast concrete wingwall of State Highway DD bridge over Shoal Creek Drainage Ditch near Dawn.
RM 2–BFE 2	706.08	Cut square on top of northwest concrete wingwall of State Highway DD bridge over Shoal Creek Drainage Ditch near Dawn.
RM 1–BFE 3	700.51	Cut square on top of northeast concrete wingwall of County Road 418 bridge over Shoal Creek Drainage Ditch near Dawn.
RM 2–BFE 3	699.46	Cut square on top of northwest concrete wingwall of County Road 418 bridge over Shoal Creek Drainage Ditch near Dawn.
RM 1–BFE 4	715.17	Cut square on top of northeast concrete curb of State Highway N bridge over Indian Branch at Sampsel.
RM 2–BFE 4	715.12	Cut square on top of northwest concrete curb of State Highway N bridge over Indian Branch at Sampsel.
RM 1–BFE 5	753.73	Cut square on top of east concrete headwall of County Road 515 culvert on tributary to Indian Branch near Sampsel.
RM 2–BFE 5	753.44	Cut square on west concrete headwall of County Road 515 culvert on tributary to Indian Branch near Sampsel.
RM 1–BFE 6	734.05	Cut square on top of northeast concrete wingwall of County Road 202 bridge over Honey Creek near Farmersville.
RM 2–BFE 6	734.71	Cut square on top of northwest concrete wingwall of County Road 202 bridge over Honey Creek near Farmersville.
RM 1–BFE 7	741.19	Cut square on top of northwest concrete handrail of U.S. Highway 65 bridge over No Creek near Farmersville.
RM 1–BFE 8	726.30	Cut square on top of northwest concrete handrail of U.S. Highway 65 bridge over Crooked Creek near Chillicothe.
RM 1–BFE 9	736.50	Cut square on top of north concrete headwall of State Highway 190 culvert on tributary to Coon Creek at Chillicothe.
RM 2–BFE 9	736.00	Cut square on top of south concrete headwall of State Highway 190 culvert on tributary to Coon Creek at Chillicothe.

**Table 1.** Reference mark elevations and locations for selected sites in Livingston County, Missouri—Continued

Reference mark number	Reference mark elevation <sup>a</sup> (ft)	Description of location
RM 1–BFE 10	738.15	Wooden stake along fence southeast of County Road 232 bridge over Blackwell Branch about 5 feet east of corner post and north of fence at Chillicothe.
RM 2–BFE 10	737.85	Wooden stake along fence southeast of County Road 232 bridge over Blackwell Branch about 130 feet east of corner post and north of fence at Chillicothe.
RM 1–BFE 11	706.96	Cut square on top of northeast concrete wingwall of U.S. Highway 36 bridge over Blackwell Branch at Chillicothe.
RM 1–BFE 12	729.74	Cut square on top of southeast concrete wingwall of State Highway K bridge over Medicine Creek near Chula.
RM 2–BFE 12	729.78	Cut square on top of northeast concrete curb of State Highway K bridge over Medicine Creek near Chula.
RM 1–BFE 13	739.91	Cut square on top of southeast concrete wingwall of State Highway KK bridge over Muddy Creek near Chula.
RM 1–BFE 14	738.43	Cut square on top of southwest concrete wingwall of State Highway KK over Little Muddy Creek near Chula.
RM 1–BFE 15	722.14	Cut square on top of southeast concrete curb of County Road 216 bridge over Muddy Creek near Chula.
RM 2–BFE 15	721.93	Cut square on top of northeast concrete curb of County Road 216 bridge over Muddy Creek near Chula.
RM 1–BFE 16	699.13	Cut square on top of northeast concrete handrail of U.S. Highway 36 bridge over Medicine Creek near Wheeling.
RM 2–BFE 16	699.14	Cut square on top of northwest concrete handrail of U.S. Highway 36 bridge over Medicine Creek near Wheeling.
RM 1–BFE 17	689.96	Cut square on top of southwest concrete wingwall of County Road 310 bridge over Campbell Creek near Bedford.
RM 2–BFE 17	689.96	Cut square on top of southeast concrete wingwall of County Road 310 bridge over Campbell Creek near Bedford.
RM 1–BFE 18	664.96	Cut square on top of northeast concrete wingwall of County Road 387 culvert on Towstring Creek near Hale.
RM 2–BFE 18	665.12	Cut square on top of southeast concrete wingwall of County Road 387 culvert on Towstring Creek near Hale.

<sup>a</sup> Above NGVD 29.